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A Study of Challenging Issues on Video Surveillance System for Object Detection

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Abstract—*Video surveillance system is an immense and active research area in computer vision, Artificial Intelligence and digital image processing applications due to their high accuracy and fast response. This paper mainly focuses on major challenging issues and targeted objects for different video surveillance systems such as observation of forestry, human activities, natural environment, and various application areas. This paper also explores various advantages of Visual Surveillance system, resources and datasets.*

1. INTRODUCTION

The word surveillance is a fusion of two words firstly, "sur" that means "from above" and secondly, "veiller" that means "to watch or observe" [1,6]. Video surveillance system is an immense and active area of research in the domain of computer vision, artificial intelligence and digital image processing. In 1930-1940's tube cameras were used for monitoring and CCTV was also expensive to observe the events via optical display. The main issue encountered with these systems is low resolution of resultant scene, it become hard to monitor incidents that occur simultaneously in surveillance display due to some constraints [7, 8, 9, 10, 11].

From the view point of real time crime or threat detection, human visible attention falls below the level of acceptance even if a well trained person is assigned with a monitoring job [1, 3]. And on the other hand, several video technologies are applied to build a smart system that can assist the operator in real time crime or threat detection [4,7, 8].

Applications of this system include various security aspects at airports, public places, banks, shopping complexes, holy places, military area, institutions, ATM machines and government agencies, pedestrian and car traffic monitoring, human behavior for freakish activity, calculating number of peoples and many more [16.17]. There are three basic building blocks of any smart surveillance system: moving object detection (people, vehicles), object tracking and higher level analysis. Several video products are widely available to monitor home nursing, office or any particular location of interest to detect abnormalities [7,8,9,10]. Using webcams this visual data is stored in a compressed form and system trigger for various vigilances such as sending messages (MMS or SMS) or emails [11,12]. The two major benefits of smart surveillances system are listed below.

- *Availability*: In the past time video surveillance system were only used in shopping malls or complexes but now a day these system are used everywhere from home nursing or small store to public or holy places. As a result they guarantee high security at a very feasible cost.
- *Real time crime or threat monitoring*: Conventionally large organisations used video surveillance systems to monitor threat or crime. During that time the incidents captured on video were used to collect important information to proof the particular event or incident. But now a day's new technologies let users to examine and reply to triggers immediately.

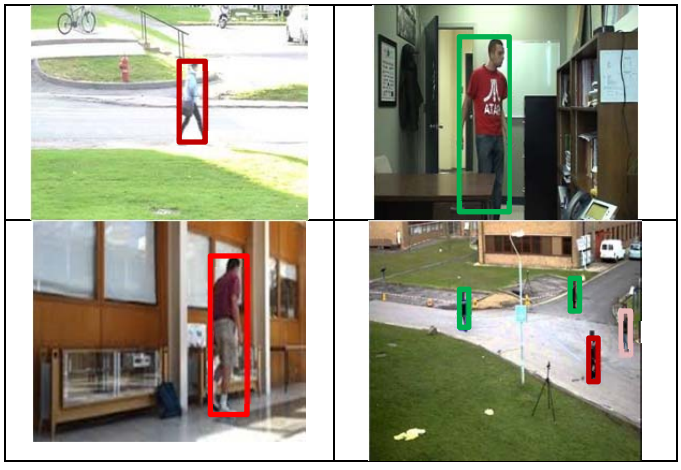

Fig. 1.1 Row 1: (a) Padestrian (b) Office; Row 2: (a) PETS 2009 (b) PETS 2014

This paper is categorised into different section, first section deals with the brief overview with major challenging issues and applications. In section 2 major challenging issues

in video surveillance system are discussed. In the next section 3, various applications of this active area are explored. Section 5 deals with various publicly available resources and datasets

2. MAJOR CHALLENGING ISSUES

In this section, various challenging issues generated due to complex nature of background are explored.

- *Dynamic Background*: Background is sometimes so cluttered it become very difficult to differentiate a pixel as a foreground or background. There are various types of background that can lead to false detection of pixel such as waving [20,25, 27, 28, 32, 33].
- *Noise image*: Digital images are often susceptible to a different kind of noise. Noisy image are result of poor grade picture source such as images taken from web cameras or images that are being compressed [14, 26, 36]. For e.g. salt and pepper noise
- *Camera jitter*: Camera shake is a chronic issue in realistic world often lead to blur motion. At sometime, camera is displaced due to motion of wind and causes nominal motion that result in detection of false images [36, 20].
- *Illumination changes:* There can be sudden changes such as light switch on or off .that can lead to illumination changes or intensity changes or in case of outdoor light intensity changes during day scenario. These sudden or gradual variations often lead to false detection of pixel [4, 6,20,21, 35, 20].
- *Bootstrapping:* During the training period in some environmental conditions background is not present. Then, it becomes very difficult to compute an illustrative background [23, 26, 28,36].
- *Foreground aperture:* If moved object has uniform coloured region than in that case changes occurs inside these region cannot be detected that result in false negative detection because entire object may not detected as foreground [26, 27, 33].
- *Moved background Object:* Sometimes background object moved and should not consider as a part of foreground. So, both initial and current object position are detected without efficient background maintenance mechanism [46, 64].
- *Camouflage:* Characteristic of foreground object are assumed on the basis of background model that often lead to miss interpretation of background and foreground pixel [27, 29]. For e.g. in case if background color is similar to foreground then, pixels corresponds to the background are falsely interpreted as foreground.
- *Inserted background object*: In case a new background object is inserted then this object cannot be considered as foreground because this object is detected without any effective maintenance scheme [4, 5, 46, 65, 66].
- *Leaves, rippling of water, water surface etc* :In some cases, flow of water is associated with small waves on the surface in the background frames and there is slow movement of leaves that result in false detection of object. Due to rippling of water or slow leafy movement background pixels are considered as foreground and lead to misclassification of pixels [9, 11,20].
- *Sleeping foreground object*: Motionless or Sleeping foreground objects can be marked as background. Due to its motionless phenomenon it becomes very difficult to distinguish non moving objects from background, then considered as a background objects [4, 5, 14, 19, 21, 22, 36].
- *Shadowing:* The appearance of shadow with moving object in computer vision leads to depletion of reliability of object detection and object tracking. Therefore, shadow detection is an active research area itself and can be detected as foreground comes from moving object or background [29,38].

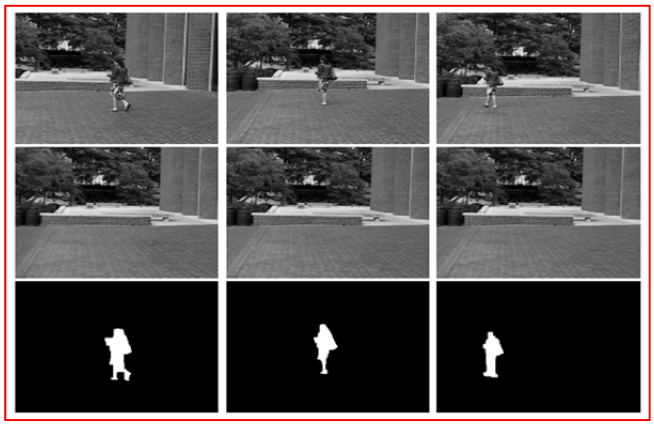

Fig. 2.1: Moving Object Detection by Detecting Contiguous Outliers in the Low-Rank Representation [20]

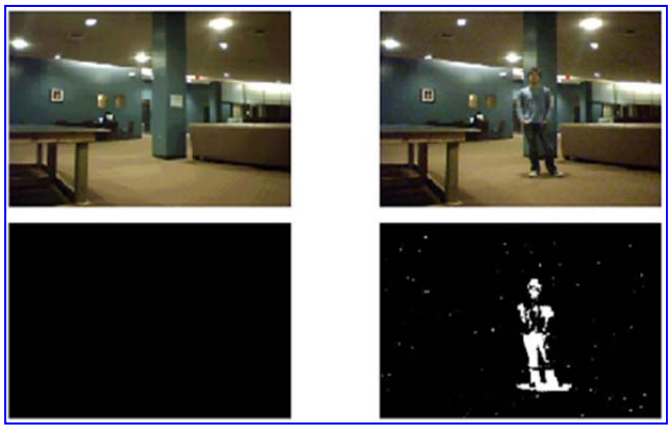

Fig. 2.2: Moving Object Detection in indoor scenarios [21]

3. AREAS OF APPLICATION

In computer vision and image processing object detection is the initial step and is an ideal choice for visual surveillance system [29, 47, 48, 49, 51, 52,53, 54] and various computer vision application areas such as:

- *Intelligent video surveillance***:** Foreground object detection and background modeling is an ideal choice for this kind of system. The main aim is to detect moving object or salient object for security purpose of particular area or for statistical computation on traffic such as in airport, roads or maritime surveillances [7, 8, 14, 17, 23, 36,]. Object of interest is quite different as compared to others. For example, surveillances can be important to judge the shopping behaviour of customer, in banking for safety purpose, battle field etc [3, 16, 17, 18].
- *Optical motion capture***:** This application deals with full capturing of human being from camera's and then silhouette can be extracted using BGS technique. This system has numerous applications in computer graphics and video gaming for character animation and realistic simulation of object movement [35,38].
- *Intelligent Visual observation of forestry***:** Visual surveillance system can also be important to check the activities or behavior of animals and insects in restricted or protected areas such as zoo's, national park, oceans, rivers etc for ethological and ecological purpose. The object of particular interest includes bees [7], fishes [10], birds [39] for avian safety and protection.
- *Human machine interaction***:** In real time several applications need interaction between machines and humans via video's captured with static cameras such as games. Sometimes, it also treated as the intersection of behavioral sciences, computer science, design, media learning and other important areas of study [3,5,26].
- *Content based video coding:* To analyse video content firstly video has to be segmented or partitioned in no. of frames to obtain the object of interest. Object is first detected and then tracked in video sequence. Then background and object are encoded separately, for this purpose an efficient and effective BGS technique is needed for object detection [1,30,32].
- *Medical surveillance***:** To provide high quality and affordable healthcare. The medical department sometime assign a person known as patient sitters to keep an eye on patient's health condition minutely at critical level or for those patients who are demented or perturbated [20, 17]. Remote Patient Monitoring results in staff cost reduction, low risk and exposure, and becomes a good mean of interaction between doctors and Patient Sitters Medical surveillance also serves as an extra set of eyes to monitor emergency or causality department as it deters criminal acts and drug divergence (i.e. to identify healthcare staff who divert drugs for their personal benefit) [23,27].
- *Biometric Identification system:* Biometrics means automatic identification or verifications of individuals based on their behavioral or physiological characteristics. In addition to faces and fingerprints of a person, signature, iris, tone of voice, facial thermograms, person's way of using key pad and the famous DNA [2, 4, 6, 10,11,28]. For example video surveillance enhanced by facial and finger print recognition technology are most commonly used biometric techniques for identification.

In the Table.3.1 given below represents an overview of various kind of visual surveillance systems where first column represents major categorization of visual surveillance system, second column gives sub categorization view of several visual surveillance system, third column indicates several challenges of surveillances system, where descriptions are as: non stationary background (NB), dynamic background (DB), slow foreground movement (SF),Moved object (MO), fast foreground movement (FO), illumination changes (IC), shadowing (SH), and background to store (IB) and fourth column represents type of object targeted.

Table 3.1: An overview: Major and sub categorization of visual surveillance system with several major challenges

Major Categories	Sub- categories	Major Challenges	Targeted Objects
Intelligent Visual Surveillances of human Activities	Traffic Surveillance	DB, SF, IC, SH	Cars, People
	Surveillance of illegal activities	NB, DB, SF,MO	People [7, 15]
	Maritime traffic Surveillance	SF, NB	Boats, people
	Surveillance of public event	NB, DB, MO, SF,IB	People [39]
	Border Surveillance	DB, NB, SF, IC, MO	People, vehicles [34]
	Aerial Surveillance	DB, SH	People, vehicles [20, 55]
	Medical Surveillance	IC, NB, DB, SH	Objects[17]
			people, vehicles[70, 11, 22, 33]
Intelligent Visual observation of Forestry	Birds Surveillance	NB, DB, IC,MO	Birds [7, 10]
	Insect Surveillance	NB, MO, SF, DB, SH	Honeybees [10, 39]
	Fishery Surveillance	SF, DB	Fish [7]
Intelligent Visual Observation of Natural Environment	River Surveillances	NB	Woods [24]
	Nuclear accident surveillance	NB, DB, SH, MO	Object , people[10]
	Surveillance of Dike	IB, NB	Object [11,20]
	Coastal surveillance	NB, DB, SF	Object [15,29]

Human Machine Interaction (HMI)	Games Ludo applications Virtual keyboard Gaze detection	DB, SF, NB, IB IB, DB SF, SH, MO, IC NB, SF	People [32, 12] People animals[10] Object, people [36] People [32]
Content based video Coding	Video Content	SF, FF, IC, SH	Video Objects [20, 21, 19]
Biometric	Face detection, finger prints detection, hand geometry, iris pattern	FO, IC, SH	People [19,27, 36]

4. ADVANTAGES OF VIDEO SURVEILLANCE SYSTEMS

Video surveillance is a very powerful security tactic for any property (e.g. crime or threat) that can happens anywhere such as home, holy or public places, banks, defence, private places and many more [12,28,19,31,32]. This system has many advantages as it is the easiest way of keep an eye for security purpose. The following are top benefits or advantages of this system

- *Act as a crime deterrent***:** The first and biggest advantage of video surveillance system is that it acts as a crime deterrent. The actual event can be recorded using these systems. If these systems are placed around home, schools, institutions or work places they act as a subsequent layer of information and prevent the places for become easy targets.
- *Apprehend a suspect when a crime or threat occurs***:** They enable us to keep an eye on each and every activity of individuals visited public or private places including banks, offices, shopping malls, schools, colleges etc. This is a great way to detect any kind of suspicious activity and keep tabs on persons with wrong intentions.
- *Evidence gathering***:** Another important benefit of this system is that they are proved to be very helpful dealing with legal matters. Sometimes the major eye witness forgot crucial details or eye witness trying to hide what actually happened. With video surveillance system, the legal authorities can comes to conclusion about the series of events actually happened at the time of crime occurs.
- *Maintain Records***:** In surveillance system visual data is saved systematically according to date and time of the event. Whether it is a case of crime or a minor tiff, surveillance system chronicles it, and it becomes easier to investigate the sequence of activities actually happened.

5. RESOURCES AND DATASETS

Various datasets are available publicly for detection of moving object from frame or video sequences. These datasets are provides realistic frames with accurate ground-truth. This paper simply, explored some of major existing datasets which are captured using non moving cameras or stationary cameras.

- *Background subtraction websites***:** This website contains links to datasets and list of references. Data is updated regularly and different background models are classified as per the information provided by this website.
- *Wall flower:* This dataset was provided by Toyama et al.[34]. This dataset provide full fledge details of seven different video sequences with obstacles that are likely to encounter like illumination or intensity changes, dynamic or cluttered background. This dataset is most widely used dataset with 160x120 pixel size of image but it has major drawback that is only one ground truth available per sequence.
- *Change detection.net (CDNET):* The dataset namely CDW[13][33] comprises of realistic, large scale video sequence nearly about 90,000 frames in 31 video sequence that represent six different categories that covers a large range of problems in two modularity's (color and thermal IR). Each frame contains ground truth or ideal foreground, background and shadowing to allow precise analysis and comparison of BGS algorithm.
- *I2R8 dataset***:** This dataset mainly consist of nine video sequences and was provided by Lin and Huang [29]. Each sequence has illumination effect or dynamic background with 176x144 pixel image size. Main advantage of this dataset is that 20 ground truth image or ideal results are provided for one individual frame sequence. There Ground truths are captured only when critical situation occurs.
- *PETS:* This dataset contains different datasets such as PETS2001, PETS2003, PETS2006 that is related to conference performance for evaluation of tracking and surveillances [62]. These are mainly used for object tracking evaluation as compared to BGS.
- *OTCBVS dataset:* This dataset is publicly available benchmark for testing and evaluation of various computer vision algorithms. The benchmark comprises of several videos sequences and images that are recorded in and beyond the visible light or visible spectrum range and are freely available without any cost to all scientific researchers and academicians in the world of computer vision [31].
- *CSIR-CSIO dataset (CSIR India):* This dataset has been provided by Council for scientific and industrial research (CSIR), India. We used this dataset for object detection on thermal video. This dataset contains gray scale video frames of thermal imaging [30].

Table 5.1: Resources and datasets

Dataset	Major Challenging Issues
Microsoft's Wall-flower Dataset[34]	Dynamic background, illumination variation, camouflage, foreground aperture, light switch on or off, bootstrapping.
Change Detection [33] Dataset	Camera Jitter, dynamic background, intermittent object motion, shadow. (http://changedetection.net/)
I2R [29]	Dynamic background or illumination variation (http://perception.i2r.a-star.edu.sg/bk_ model/bk_index.html)
CSIR-CSIO Dataset [30]	Background motion, illumination variation. (http://www.vcipl.okstate.edu/otcbvs/bench/)
OTCBVS Dataset [31]	Moving person with moving background in thermal imaging (http://www.vcipl.okstate.edu/otcbvs/bench/) (http://www.cvc.uab.es/~ivanhc/ObjDect/huertaDect.html)
PETS Dataset [32]	Background motion, illumination variation (*http://ftp.pets.rdg.ac.uk/pub/*)

6. CONCLUSION AND FUTURE WORK

This paper mainly explores major challenging issues and targeted objects for different video surveillance systems such as observation of forestry, human activities, natural environment, and various application areas. This paper also explores various benefits of Video Surveillance system, resources and datasets. In future we will capture some data from video sequence and then apply cloud to store of retrieve data from cloud for further processing.

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