International Journal of Advance Engineering and Research Development (IJAERD)
Volume 1,Issue 5,May 2014, e-ISSN: 2348 - 4470 , print-ISSN:2348-6406

Intelligent Home Security System using illumination sensitive background model

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Abstract: Home security has been a concern of worldwide. The need of security systems is considered as one of the important aspects of our modern life, people are using such systems to be aware about anything could be happen in their places like their houses when they are away, these system also let them feel more secure and that is what the people really need. As the technology is developing, rich home based security systems are implemented to ensure safety and security of. Video surveillance is an important area of computer vision research, its applications including both outdoor and indoor automated surveillance systems Home security system is an essential mean of protecting our home from illegal invasion. A conventional home security system consists of a Closed Circuit Television, CCTV and burglar alarm which can be replaced by computer based systems with the capability of smarter detection and alert system. In the context of smart home environments, the In-House Video Surveillance systems have as main goal to control the safety and the security of materials and of people living in a domestic environment. This paper provides a comparative approach between tracking learning and detection algorithm with illumination sensitive background model. Further a face recognition module is implemented which has the capability of identify intruder. On finding the intruder, the system sends an email on the owner mail id with images of the intruders so that the further action can be initiated.

Keywords: Home Security, Video surveillance, Motion detection, TLD, ISBM, PN Learning, Face Recognition, Communication methodology.

I. INTRODUCTION

Security is one of the biggest issues in today's world. The current home-security service system in market included preventing thieves from intruding, monitoring and control system, fire control etc. Even though all of them were comprehensive, yet there still were some defects among them such as the consumers must construct cooperative relationship with security supplier, and this condition resulted in high expenditure for service quality as well as much difficulty in maintain and discriminating of responsibility. The existing system can be broadly categorized into

1. Microcontroller circuit based
2. Microprocessor based

Video surveillance in smart home environments, attempts to detect, recognize and track persons from image sequences, and more importantly to understand and recognize their actions and activities. Video surveillance systems in smart home environments can be classified as: (a) centralized systems, where human activity analysis is performed on a centralized server, and (b) distributed systems, where analysis is performed on a distributed cameras network. In general, an in– house video surveillance system includes, as presented in Figure 1, the following modules: (a) motion detection, (b) object tracking, and (c) human motion analysis.

Computer vision based solutions have the potential for very discriminating detection and very low false alarms. The bottom line is that applied computer vision has the potential for the greatest return on investment (ROI), both short-term and long-term. The research in the field of vision surveillance meets with the research in several smart home techniques, especially in two important demotic aspects: home health, and home security

An indoor surveillance system attempts to detect and recognize objects of interest from video

obtained by one or more cameras along, eventually by fusion information obtained from cameras and other sensors installed in the monitored area.
The output of video surveillance aims in determining decision on the object detected. The action can range from raising an alarm as in conventional security systems to sending automated short messages on owners cell phone and automatic e mails with pictures from house to the house owner. There is surely a need for a system which can act as a surveillance for our offices and home and which is easy to use, which can run on a PC, which can be accessed via different medium like mobile phone, e mail or PDA.

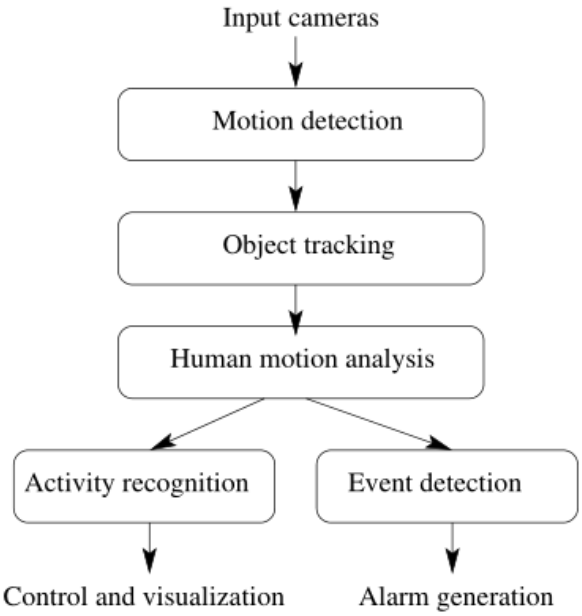


Figure 1: Traditional processing in in-house surveillence

II. REQUIREMENTS OF HSS

A security system isn't very reliable unless it is able to monitor your home for potential threats and then alert someone when it detects such threats. Monitoring services generally provide professional security systems as part of their service contracts. These services will watch over your home 24 hours a day, and will send police, fire and rescue personnel if an alarm is triggered. If you have cellular or internet monitoring as part of your security system, you can get instant notifications of any activity detected in your home. As stated in [7] a home security system must satisfy these requirements ideally. The requirements were classified as functional requirements and non-functional requirements which are as follows:

2.1. Functional Requirements:

- The system should be a distributed system.
- The system should be able to capture video.
- The system should be able to detect motion from the captured video.
- The system should able to take snapshots of the moving objects/intruder.
- The system should be able to send SMS in real time to notify the stakeholder (person interested in the security of the premises).
- The system should be able to generate automated emails for notifications.
- The system should be able to handle more than one client at the same time (Multi-tasking/Multi-threading).
- The system should be able to transfer the snapshots to distributed location for permanent storage, so this could provide accessibility to stakeholder to see them from remote location.

- The system should also provide web-based front end for users to register and download software.
- The system should be able to restrict unauthorized access.
- The system should have GUI at the client side of the system for users to interact with the system.

2.2. Non Functional Requirements:

- The system should be robust.
- The system should be user friendly
- It should be operating system independent.

III. APPROACHES OF HSS

The efforts of detection of intruders in done using microcontroller based systems. Yanbo Zhao and Zhaohui Ye [16] had designed and implemented a low cost, low power consumption, and GSM/GPRS (Global System for Mobile Communication/General Packet Radio Service) based wireless home security system is dealt with . The system is a wireless home network which contains a GSM/GPRS gateway and three kinds of wireless security sensor nodes that are door security nodes, infrared security nodes and fire alarm nodes. The nodes are easy installing. The system can response rapidly to alarm incidents and has a friendly user interface including a LCD (Liquid Crystal Display) and a capacitive sensor keyboard. The wireless communication protocol between the gateway and the nodes is made suitable for other home appliances. The system represent that GSM/GPRS is more convenient and reliable than internet. The system has the shortcomings like need of two processor architecture, Simple sensor based system with no use of cameras for intruder detection, inability to identify residents, manual setting is to be done with keyboard, use of microprocessor at every sensor and alarm is ON and SMS is send in all the situations

John See, and Sze-Wei Lee [17] propose an integrated dual-level vision-based home security system, which consists of two subsystems – a face recognition module and a motion detection module. The primary face recognition module functions as a user authentication device. On an event of a failure in the primary system, the secondary motion detection module acts as a reliable backup to detect human-related motions within certain locations inside the home. Novel algorithms have been proposed for both subsystems. Several experiments and field tests conducted have shown good performance and feasible implementation in both subsystems. The Vision-based security system having the advantage of easy to set up, inexpensive and non-obtrusive. The system poses the advantages like - unobtrusive and user-friendly vision based system, User authentication and intruder tracking from distance, No need of human intervention, No need of human contact with sensors and Setup being easy and inexpensive. The system also has the cons like - requirement two processors for operations, One camera only monitors door/entrance, System based on human motion detection, heavy computations for Fuzzy rule based classification scheme and system alerts only security alarm

The efforts of Young-Keun Choi et al [21]] recommend a new algorithm to detect the intruder in room. The basic idea of the proposed method is to estimate the variation of features of the room acoustic transfer function (RTF). Several simulations and actually tests show that the proposed method provides good performance for intruder detection. The system has the disadvantages like highly sensitive to Room transfer function, requirement of speaker and microphones, more power consumption and system alerts only via alarm.

Recent progress in wireless technologies has led to the renovation in building automation which makes it possible to upgrade the existing building without destroying the original interior decorations. Jun Hou et.al proposed an intelligent home security system based on Zigbee [15] which can monitor the important positions inside a home through a surveillance camera. The home state SMS and image Multimedia Message Service (MMS) can be sent to mobile phones. Zigbee modules are used to connect the system motherboard with temperature and gas sensors, forming a Wireless Sensor Network (WSN). But this system requires an expensive and high end system mother board

for controlling and managing the WSN. Vivek Nainwal et.al proposed a system which explores WSN for remote surveillance [8]. Sensors are used to detect the presence of objects in the surveillance area and the information is collected over time to extract the event of interest. The information gathered by the surveillance camera i.e. video or still images could be used for further analysis and detection of the intruding object. But the proposed system uses the traditional sensor alarm method for user notification and does utilizing advanced alerting techniques like call making.

Advantages of computer based approach

- □ High stability: Run continuously for more than 300 days.
- High operation of file storage: The file name and its path express time and location information.
- □ Minimum necessary storage: Simple picture selection software has been adapted. The software saves a picture only when the difference between two consecutive pictures exceeds the threshold.
- □ Automatic delete: Folders that are older than the save period set by the owner are automatically deleted.
- □ Compatibility with many types of cameras: The software can operate in the VFW mode (PC cameras and USB video adapters) and the FTP mode (network cameras).
- □ Simultaneous operation: The software can operate several cameras connected to a PC.

IV. MOTION RECOGNITION

4.1. Motion Detection

Motion detection methods attempt to locate connected regions of pixels that represent the moving objects within the scene. Conventional approaches for motion detection methods use background subtraction, temporal differencing and optical flow. As the name indicates background subtraction consists in subtraction of a background or reference model from the current image followed by a labeling process. Recent background subtraction algorithms focused on adapting to varying illumination conditions, geometry reconfiguration of background structure, and repetitive motion from clutter. Among others may include methods such as: (a) background subtraction methods for modeling a multiple modal background distribution [12], which use a Gaussian– based approach for real– time applications, (b) statistical background modeling [13], where an edge segment– based statistical background modeling is used, and (c) universal background subtraction algorithm for video sequences [9], which stores a set of values taken in the past in the same location or in the neighborhood. In temporal differencing the subtraction of two or more consecutive frames followed by thresholding is applied. The optical flow approach uses the velocity field that warps one image into another image.

Table 01: Comparison between methods

Method	**Merits**	**Demerits**
Background subtraction	Simple	Extremely sensitive to changes in light
Temporal differencing	Robust to dynamic changes of the environment	Poor results in case of moving objects
Optical flow based	Retect independently moving objects even in the presence of camera motion	Computationally complex and very sensitive to noise Cannot be applied to video streams in real time without using specialized hardware

4.2. Object Tracking

The object tracking module is responsible for detecting and tracking of moving objects by using information from the motion detection module, object locations being subsequently transformed into 3D coordinates. There are several approaches to classify object tracking methods. According to [20],

object tracking can be classified into (i) region-based tracking, (ii) active contour-based tracking, (iii) feature-based tracking, and (iv) model-based tracking.

4.2.1 Tracking Learning Detection (TLD)

Tracking Learning Detection [1][3] is a framework for tracking an unknown object in a video stream which is designed for long-term tracking. Its block diagram is shown in figure 2. Tracker and Detector form the components of the framework.

Motion between consecutive frames is estimated by tracker. Tracker assumes that frame-to-frame motion is limited and the object is visible. Operation of tracker may be unsuccessful and never recuperate if the object moves out of the camera view. Detector, on the other hand, considers each frame as independent of other performing full scanning of the image. It tries to localize all appearances that have been observed and learned in the past. During its operation, the detector makes two types of errors: false positives and false negative. The outcome of tracker and detector is learning. Learning scrutinizes actions of tracker and detector, approximates errors in the detector and as an outcome generates training sets which try to avoid the errors in the subsequent frames being supplied for analysis. In the focus of learning, the detector generalizes to more object appearances and discriminates against background.

Figure 2. The Block Diagram of the TLD framework

The learning component of the TLD framework aims to improve the performance of the detector. This is achieved by processing the incoming video stream with the evaluation of the current detector for identifying errors and updating them thereby avoiding such errors in subsequent frames. Errors in the detector are rectified using two components which can be called as “experts or specialist” of the learner as shown in figure 3. These are identify errors as P-expert identifies only false negatives, N-expert identifies only false positives. Further the experts themselves make errors, however, their independence enables mutual compensation of their errors.

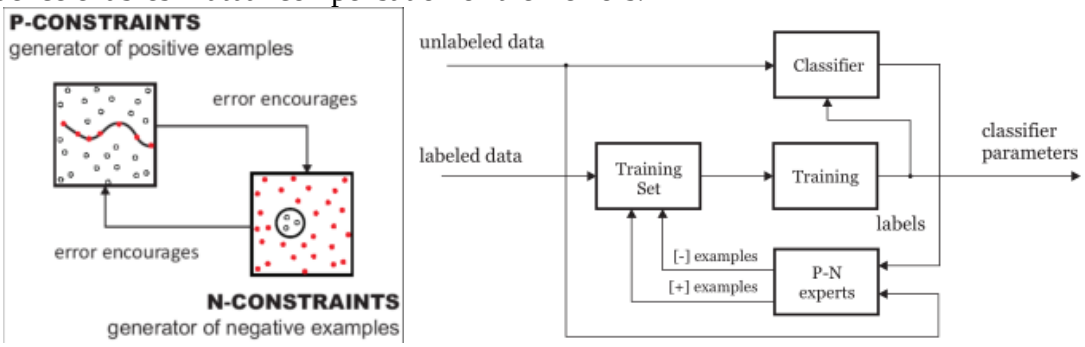


Figure 3. PN Constraints and Block Diagram of PN Learning

4.2.2 Illumination sensitive background model

An illumination-sensitive background modeling approach [2] as depicted in figure 4 is a method to

identify moving objects in scenes which involve the illumination change. The approach overcomes the limitation with many background subtraction approaches which cannot update the current status of the background image in scenes with sudden illumination change. This type of problem is typically significant in regard to motion detection when light is suddenly switched ON or OFF. The system uses two background candidates, including a light background image and a dark background image. Based on the background model and illumination evaluation, the binary mask of moving objects can be generated by the proposed thresholding function.

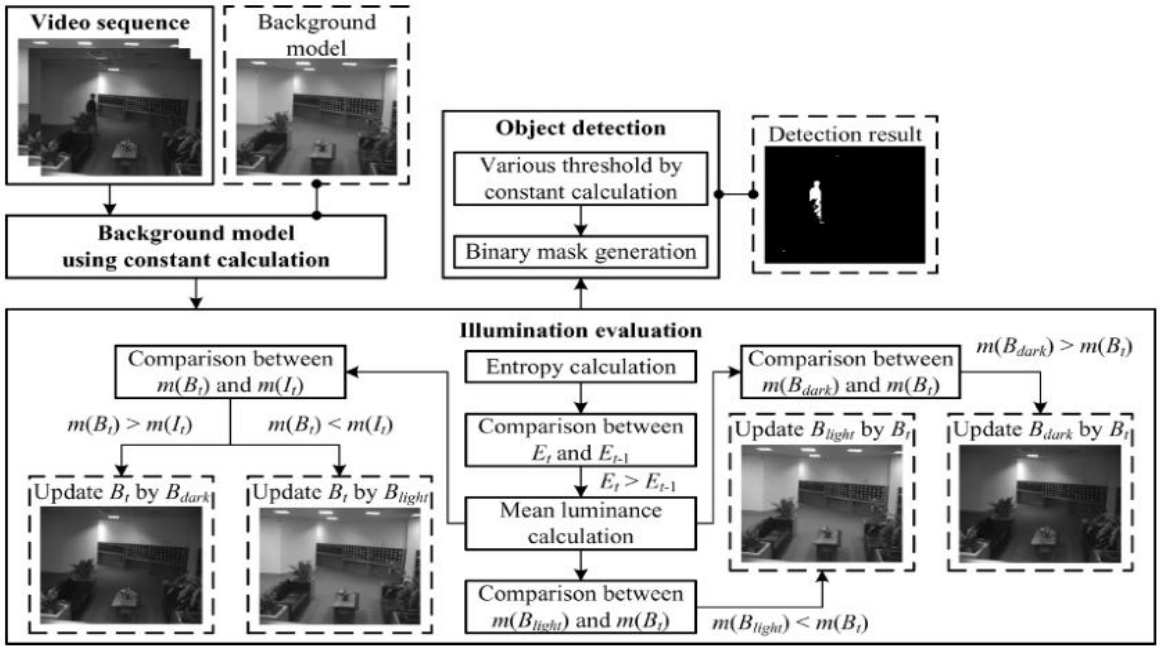


Figure 4. Block Diagram of ISBM

Face recognition is the task of identifying extracted face from an image as a known face or unknown face. During the task of face recognition first it is necessary to discover an object as a "face" and locate it with proper coordinate in the input image while in the process of face recognition it is required to decide if this "face" is someone known or unknown depending on the database of faces it uses to validate this input image. Given an image for examination, the input image is first analyzed to detect one or more faces at proper location and then the recognition of the face includes the process of extracting and matching the features with all the images present in the face database. Face recognition system generally falls into two categories: verification and identification. Face verification is considered as one to one match that compares a face image against a template face image whose identity is being claimed. Further, face identification is a one to many type of problem that compares a query or input face image against all image templates in a face database. The process is shown in figure 5 Face recognition is quite a important issue in pattern recognition, neural networks, computer graphics, psychology and image processing. Face detection is the first step in any automated system which solves the above problems.

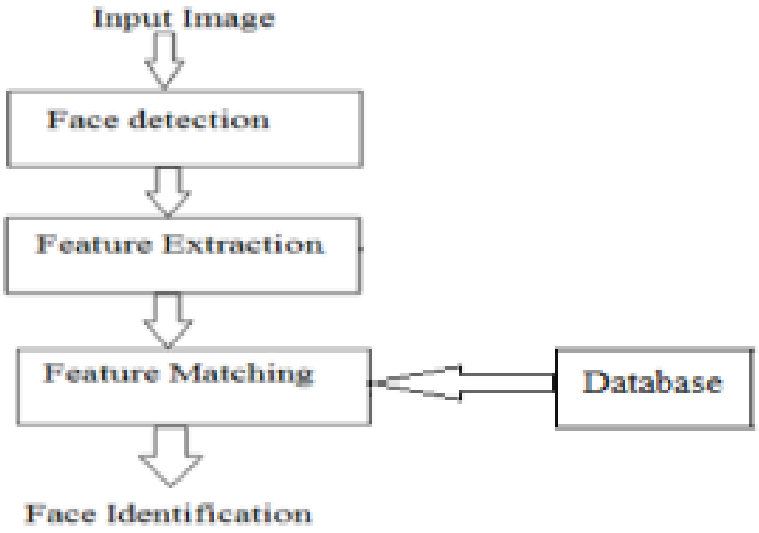


Figure 6 Block Diagram of Face Recognition

V. EXPERIMENTAL SETUP

The proposed work focuses on improvements in detection of intruders inside the house. For performance evaluation of the system 10 datasets are created. Each datasets contains 1680 images which are snapped at regular interval using digital camera. Out of the snapped images few images contain moving objects. Further for observing performance of the system under the influence of illuminance, the datasets are taken at different intervals of day and night. The images are of high resolution (1600 x 1200 pixels) for better extraction of intruders.

Stage 1: Generation of Background Model

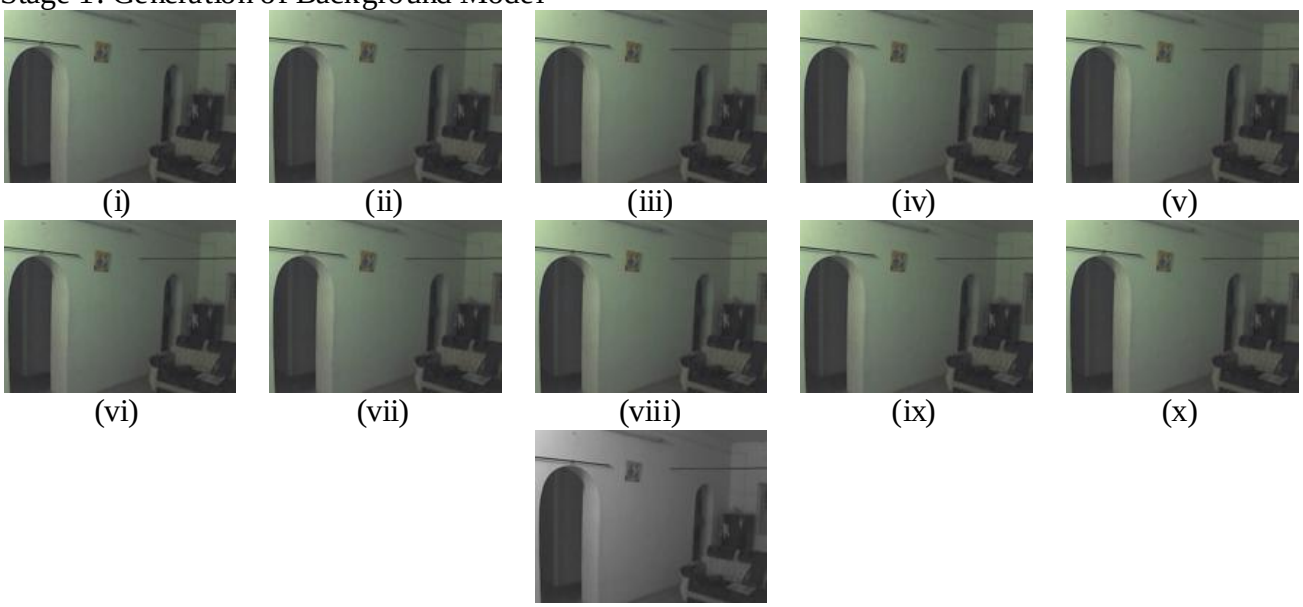
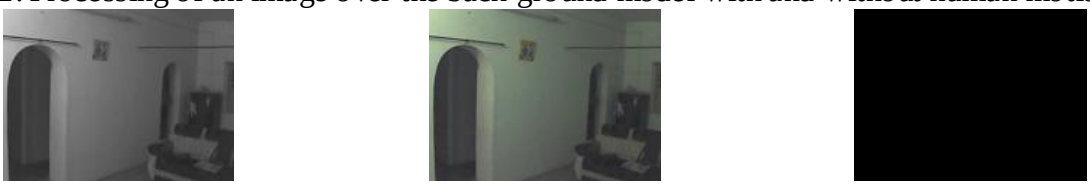


Figure 7. (i) – (x). Images used for generation of background model, (xi) – Generated background model

Stage 2: Processing of an image over the back ground model with and without human motion



(xii) (xiii) (xiv)

Figure 8. (xii) – Background Model, (xiii) – Image for processing, (xiv) – No motion detected



(xv) (xvi) (xvii)

Figure 9. (xv) – Background Model, (xvi) – Image for processing, (xvii) – Motion detected



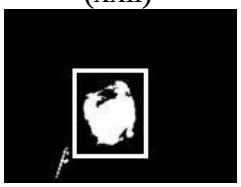
(xviii) (xix) (xx)

Figure 10. (xv) – Background Model, (xvi) – Image for processing, (xvii) – Motion detected

Stage 3: Identification of object of interest




(xxi) (xxii) (xxiii) (xxiv)

(xxv) (xxvi) (xxvii) (xxviii)

Figure 10. (xxiv) and (xxviii) – Extracted object of Interest for further processing

Stage 5: Comparison of extracted object with database for identification of intruder


(xxix) (xxx)

Output:

Resident

(xxxi)

No such image in database

Output:

Intruder

Figure 11.Identification of Resident and Intruder by comparing extracted faces with database of faces

Stage 6: Retrieval of SMS and email by the owner if intruder is detected.

Figure 12.SMS and Email as received by the home owner on detection of intruder

VI. RESULTS

After performing experiments on the datasets following results were obtained. The graphs clearly indicate the improved performance over tracking learning and detection algorithm.

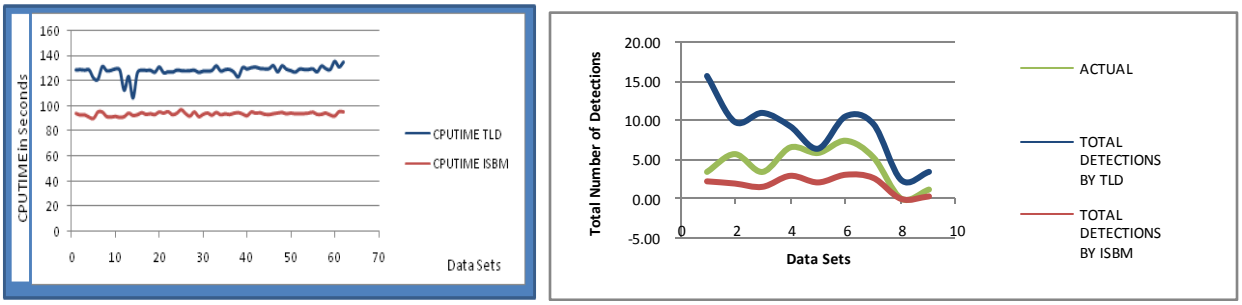


Figure13. Comparison of TLD and ISBM for CPUTIME and Number of Detections

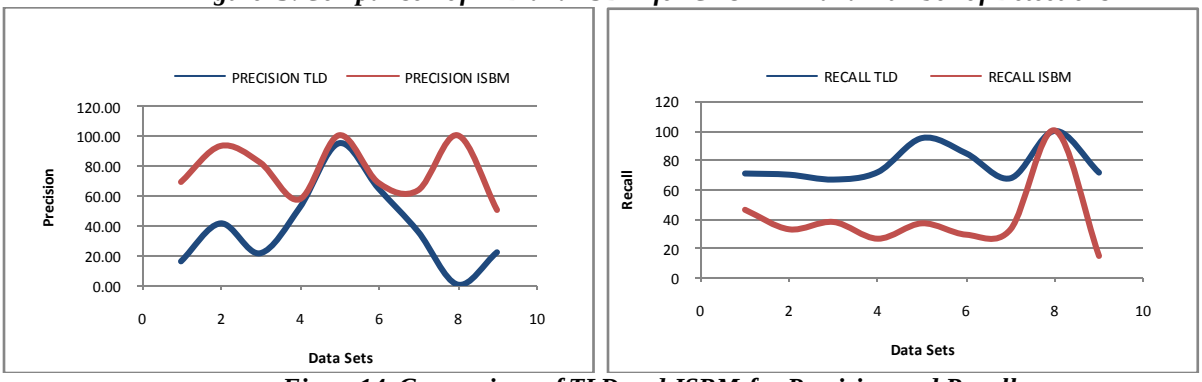


Figure14. Comparison of TLD and ISBM for Precision and Recall

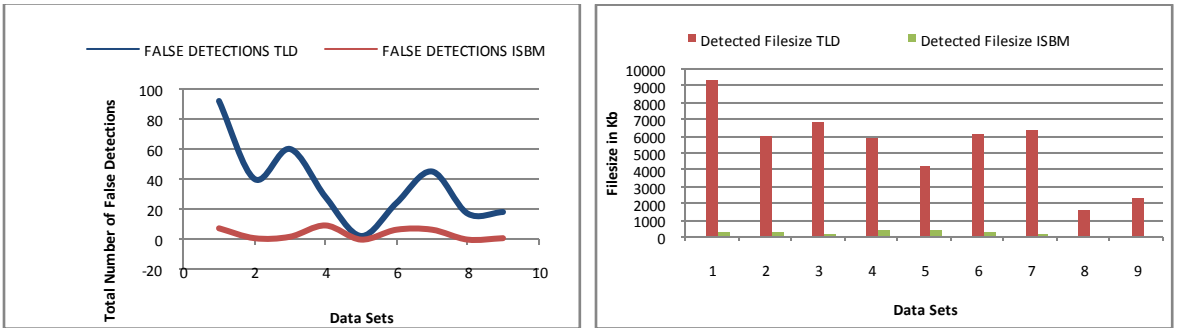


Figure15. Comparison of TLD and ISBM for False detections and file size

VII. CONCLUSION

Illumination Sensitive Background model clearly outperforms under variable lighting conditions. The result section show much better performance over the tracking learning and detection (TLD) algorithm. The system not only very efficiently identify intruders at any day of time but as the background model updates itself automatically the system also has the capability to ignore difference in subsequent images due to illumination. Also the system is set to consider sufficiently larger moving objects by setting appropriate value of threshold, hence flying curtains, pets, wall lizards etc are automatically ignored. The filesize of images sent on email is also considerably lower which reduces the uploading time. With the use of more better face recognition program the system could be developed into an efficient and intelligent home security system.

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