Object Detection in Motion Estimation and Tracking analysis for IoT devices

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Abstract:

Object detection is most prevalent step of video analytics. Performance at higher level is greatly depends on accurate performance of object detection. Various platforms are being used for designing and implementation of object detection algorithm. It includes C programming, MATLAB and Simulink, open cv etc. Among these, MATLAB programming is most popular in students and researchers due to its extensive features. These features include data processing using matrix, set of toolboxes and Simulink blocks covering all technology field, easy programming, and Help topics with numerous examples. This paper presents the implementation of object detection and tracking using MATLAB. It demonstrates the basic block diagram of object detection and explains various predefined functions and object from different toolboxes that can be useful at each level in object detection. Useful toolboxes include image acquisition, image processing, and computer vision. This study helps new researcher in object detection field to design and implement algorithms using MATLAB. It is related to many real time applications like vehicle perception, video surveillance and so on. In order to overcome the issue of detection, tracking related to object movement and appearance. Most of the algorithm focuses on the tracking algorithm to smoothen the video sequence. On the other hand, few methods use the prior available information about object shape, color, texture and so on. Tracking algorithm which combines above stated parameters of objects is discussed and analyzed in this research.

Keywords: *Matlab, Object Modeling, Object tracking, Object Detection, Object Representation, Kalman Filter, Morphological Operation.*

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1. Introduction

Visual Object Tracking (VOT) is a relative1ly modern phenomenon occurred within the computer vision discipline. It is based on principles, which are linked to image or video frame processing. The data contained within this image or frame is captured and analyzed based on specific parameters, which allow an output to be generated accordingly. Two key steps facilitate this capability that includes detection and representation of the object. Detection involves determining object existence whilst representation involves its detection [1-2]. Object tracking is therefore concerned with verifying the existence of an object within a video frame. Object tracking can be defined as the estimation of object trajectory in the image plane as it moves from one frame to another. Tracking works through permanent label assignment of an object present in many video frames.

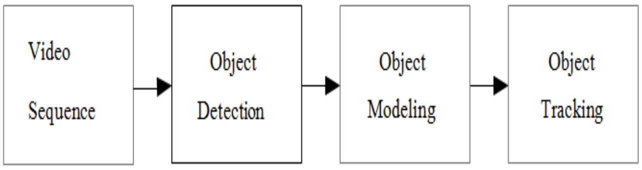

Fig.1: Block diagram

Object tracking can be approached in different ways based on factors such as suitability of object representation, specific use of image features, and object modeling parameters such as shape, appearance and motion [3-5]. These factors are contingent upon the object and its environment. As a consequence, many tracking methods have been developed which take into consideration the aforementioned factors whilst stressing specific features over others. The accuracy of tracking is contingent upon two factors including object detection and modeling. The flow diagram in Figure 1, illustrates the main steps associated with object tracking. The first step of tracking objects in a video sequence involves object detection. This helps us to determine which object needs to be tracked followed by modeling presence of the object within a single frame. The last stage involves specifically focusing on, and tracking the desired object. Object detection involves determining semantic object instances of a specific class. For example, cars, boats and humans within digital videos and images [6-8]. The most important step in object tracking involves object detection mechanisms, which operate on a frame by frame basis or as the object first appears in a video. The most common method for detecting objects is to use single frame information. However, more advanced methods make use of temporal data computed from several frames in order to minimize the number of detections [9-12].

Frame Differencing: This method is used in environments with static backgrounds with moving objects. In fact, objects of tracking interest are not stationary. They appear in different positions in consecutive frames. It is possible to determine objects, which are moving by calculating the difference between two consecutive frames and isolating, where the movement is occurring [13-15]. This form of detection is relatively easy and simple to carry out.

Optical flow: This method which makes use of pattern of the apparent object motion and edges in video sequences based on relative motion between an observer and the scene is known as optic flow. This method works by calculating the image optical flow field and carryingout clustering based on image optical flow distribution characteristics [16-17].

Background Subtraction background: The object of interest is typically located within the image foreground, whilst the background is typically of negligible interest. Removal of background from a video frame leaves the foreground, that containing the object of interest. Background subtraction is more effective when the background is already knownIt is possible to split a video sequence into complementary foreground [18-19].

Non Recursive methods: This method uses a sliding window approach to estimate the background by storing a buffer of the previous L video frames. It then estimates the background through temporal variation analysis of each pixel in the buffer. Due to this fact, only limited frame numbers are held in the buffer, errors caused by frames outside the buffer limit are not considered [20-21].

Recursive methods: This method does not make use of a buffer for background estimation. Rather it updates a single background model recursively using an input frame. This means frames from a long time ago may impact the background model. Relatively speaking, recursive methods need less storage capacity; however, a background error may linger for a longer time. Recursive methods which are commonly used nowadays include the mixture of Kalman filtering and approximated median filtering [22-24].The main problem associated with background subtraction is spontaneously updating the background from each and every incoming video frame. This problem is compounded through problems such as bootstrapping, camouflage, shadows, memory, illumination changes and motion taking place in the background itself.

Object modeling: This plays a vital role in tracking because it categorizes an object of interest. Therefore, choosing the correct object model is critical for different applications. The object model defines the feature of interest and is used to estimate tracking. Object modeling has two features, the first is object representation, and the second includes the features used to characterize an object. Effective tracking is contingent upon the correct object model selection.

The range of object representations takes into account different models which are best suited for slightly different circumstances [25-27]. For example, certain circumstances require only simple models, whereas, other situations require complex object models to achieve effective tracking. It is possible to represent an object by determining its size and shape. The most common way of doing this is through the use of skeletal models, articulated shapes, contours, silhouettes, points and primitive geometric shapes such as ellipses Maintaining the Integrity of the Specifications.

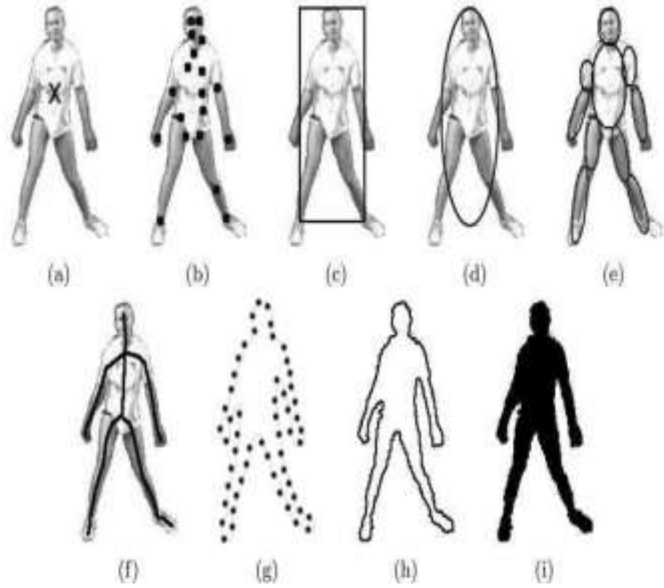

Fig.2: Object representations. (a).Centroid (b).Multiple points (c).Rectangular patch (d).Elliptical patch (e).Part-based multiple patches (f).Object skeleton (g).Complete object contour (h).Control points on object contour (i).Object silhouette.

Detecting Algorithm on Matlab

Step 1: Video Input

It can be stored video or real time video.

Step 2: Preprocessing

It mainly involves temporal and spatial smoothing such as intensity adjustment, removal of noise. For real-time systems, reduces computational cost and time.

Step 3: Object detection

It is the process of change detection and extracts appropriate change for further analysis and qualification. Pixels are classified as foreground, if they changed. Otherwise, they are considered as background. This process is called as background subtraction. The degree of "change" is a key factor in segmentation and can vary depending on the application. The result of segmentation is one or more foreground blobs, a blob being a collection of connected pixels.

Step 4: Post processing

Remove false detection caused due to dynamic condition in background using morphological and speckle noise removal.

Step 5: Change detection net dataset

The CDW29 dataset presents a realistic video dataset consisting of 31 video sequences which are categorized in 6 different challenges. Color and Thermal IR type of video included in dataset.

Step 6: BMC 2012 dataset

This dataset includes real and synthetic video. It is mainly used for comparison of different background subtraction techniques.

Step 7: Fish4 knowledge dataset

The Fish4 knowledge 35 dataset is an underwater benchmark dataset for target detection against complex background.

Step 8: Carnegie Mellon Dataset

The sequence of CMU25 by Sheikh and Shah involves a camera mounted on a tall tripod. The wind caused the tripod to sway back and forth causing vibration in the scene. This dataset is useful while studying camera jitter background situation. Stored video need to be read in appropriate format before processing. Various related functions from image processing (IP) and computer vision (CV) toolbox can be used. color spaces such as LAB, YUV and HSV have been developed since they are more capable of representing color in a perceptually uniform manner.

2. Literature Survey

The research of multiple object tracking (MOT) problem has been a long time. In recent years, the problems of object detection and tracking under the UAV scenes has aroused the attention of researchers. More and more large-scale datasets based on drones are also appearing, such as Stanford Drone Dataset (SDD), DTB70 dataset [28-32]. In order to tackle the various challenges of MOT under drone scenes, we need to consider the effective use of the motion and appearance information, better data association strategy and more accurate object detectors, etc. Many related works have thoroughly studied about these issues.

The task of object tracking is to predict the position of the object. Due to the dramatic camera motion under the drone scenes, the prediction becomes more complicated. In some earlier works, the Kalman filter is a commonly used motion estimation method in MOT, predicting the target state of the current moment from the target state at the previous moment [33-38]. Recently, with the development of deep learning, the motion models based on RNN and the Long Short Term Memory (LSTM) have achieved better results. The optical flow is an effective way to describe motion between frames within a video. The traditional Lucas–Kanade algorithm gives a method for solving sparse optical flow, which has been widely used. With the explosive progress of convolutional neural network, the method of estimating the optical flow directly by CNN has also been proposed [39-43]. The optical flow directly using a well-trained encoder-decoder network and can be used for dense optical flow estimation.The appearance feature is a more discriminative representation of the object, which can distinguish between objects effectively when they are similar. It is very helpful for crowded objects and scenes where there are lots of interactions among objects. In earlier works, the color histograms and some hand-crafted features are commonly used as descriptors of the appearance of objects. With the popularity of deep neural network, deep feature based appearance representations are increasingly used to enhance the discriminative power of appearance features [44-52]. A wide residual network to extract the features of objects and measure the similarity of objects with cosine distance. The network architecture proposed and train the network on a combination of several large-scale person reidentification datasets to extract the features of objects, which takes Euclidean distance as the metric of similarity of objects. Siamese network to learn discriminative features from detected objects. The appearance features of the detected objects using a residual network trained on large-scale re-identification datasets and distinguish them by calculating the cosine distance between two objects [53-58].

Data association is a key step in tracking-by-detection based MOT methods. Many offline MOT methods treat data associations as graph-based optimization problems. Hungarian algorithm is another commonly used data association optimization method. Further introduce a differentiable operator to build a deep Hungarian network. We simply replace the greedy data association way in IoU Tracker with the Hungarian algorithm. In addition, we design a cascade data matching method by repeatedly utilizing the motion information and appearance features of the objects [59-64] .As a part of tracking-by-detection based MOT algorithm, object detection has a great impact on the performance of the trackers. Both false positives and missing detections directly affect the evaluation metric of MOT, and indirectly lead to ID switches, so a better detector can greatly improve the accuracy of MOT. In earlier times, pedestrian or vehicle detectors based on DPM played an important role in MOT [65-69].

Since the objects under drone shooting are small and crowded, we need realize better object detectors to improve the poor performance of MOT. We compare the tracking results of Faster R-CNN and several improved algorithms in this paper, showing the big impact of object detector on MOT.

3. Overview of Proposed Scheme

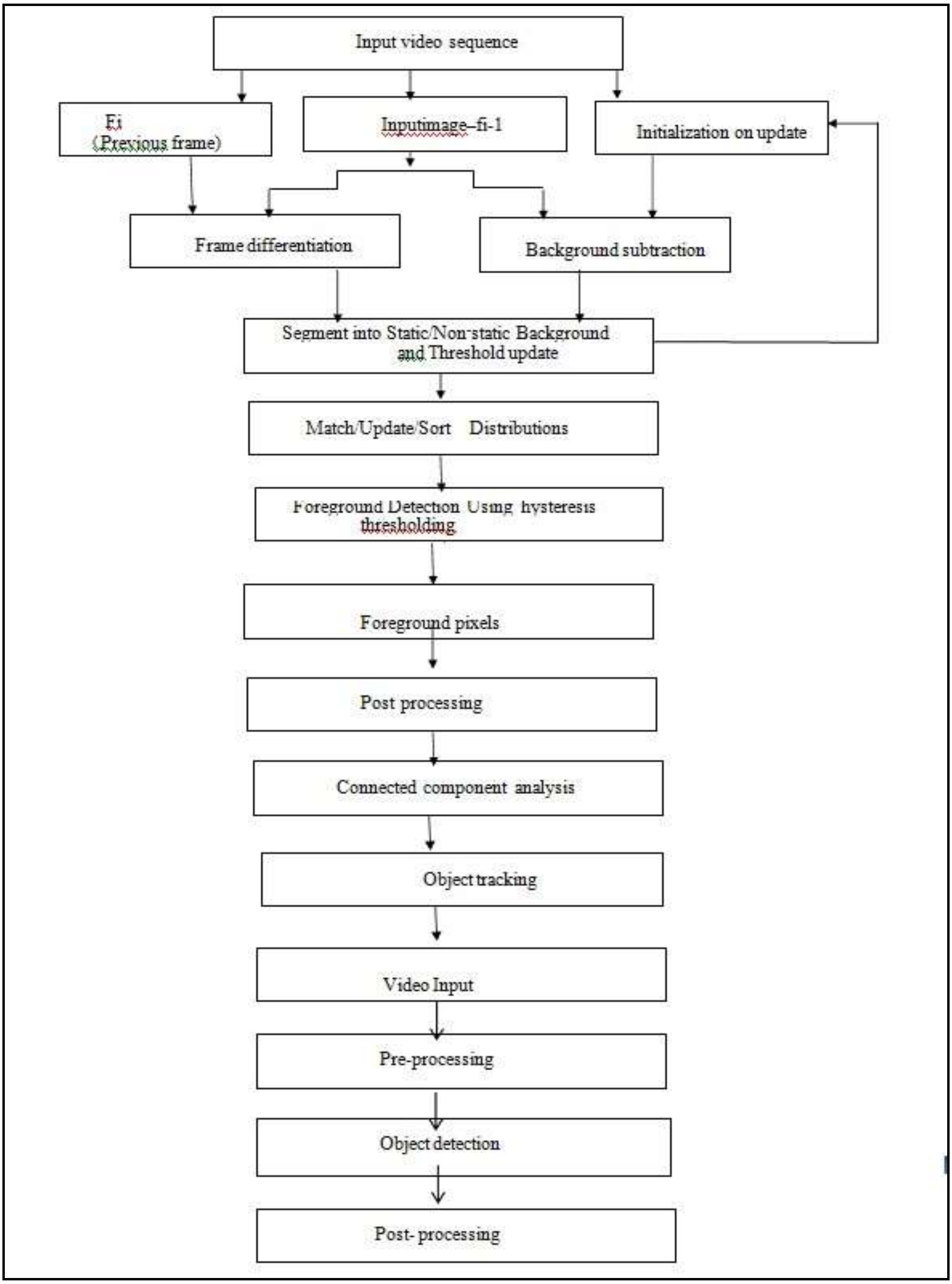

Fig 3: Flow chart of object detection

An overview of the entire moving object detection and tracking system. The technique combines Frame differencing, adaptive background subtraction and MOG to reduce the computations of MOG and improve its accuracy by focusing the attention on the most probable foreground pixels [70-72]. This proposed system able to detect and track moving object in a given scene. The system uses stationary camera to acquire video frames from outside world. The system starts by feeding video frames from a static camera that supposed to monitor a given site. The system can work both indoor as well as out door. The first step of our approach is identifying foreground objects from stationary back ground. Here we use hybrid adaptive scheme algorithm, to identify the foreground object. Next step is post processing to remove noises that cannot handled by proposed system [73-76].

After applying post processing, connected component analysis will follow and group the connected regions in the foreground map to extract individual object's feature such as bounding box, area, center of mass etc. The final step of this system is tracking. The tracking algorithm is interring frame differencing (IFD). This algorithm uses object features to track objects from frame to frame [77-80].

Object features: In the context of image processing, a feature can be understood as the simplest piece of data used for sorting out the computational task for a dedicated application. Thefeature typically is linked to a specific image structure and includes example such as texture, object, edges, etc.

Color modeling: Two physical factors influence the color of an object. Firstly this includes the spectral power distribution of the illuminate, and secondly the object surface reflectance attributes. During the acquisition of an image, the RGB color space is commonly used todisplay color. However, RGB cannot be considered as being perceptually uniform. In other words, there is a difference between the rendered RGB colors and those perceived by the human eye.

Shape modeling: This can only be applied to the geometric shape of an object and cannot be applied to the structural analysis. It is contingent upon extracting geometry of regions such as boxes and ellipses which highlight object motion and thus facilitating classification. Through a variety of methods including using points, silhouettes, and boxes. Edge is also used as a feature, where image intensities differ depending on object boundaries and can be detected using edge detection methods. The key feature of edges includes being minimally sensitive to illumination changes relative to 5.

Color features: The majority of algorithms use Edge as the main agent in tracking objects.

Motion modeling: This method is based on the principle that object motion patterns and attributes are sufficient to distinguish it from other objects. For example, the motion of human beings has been shown to be distinct from other animals. Therefore, features such as motion can be used to recognize types of human movement, in addition to human identification.

Object tracking methods: Following object detection and correct modeling, the next step involves tracking. Object tracking can be defined as a process which tracks an object over a time period by locating its position in each video frame. There is three main object tracking classifications including point, silhouette and kernel based tracking. In the case of point tracker detection, this takes place in every frame [81-82].

Point-based Tracking: This method represents an object using points and the correlation between these points is based on points of the previous frame. There are a wide number of algorithms available for point tracking purposes including Kalman Filter, Particle filter.

Kalman Filter: This method is used to determine the linear system state where Gaussiandistribution has taken place. Tracking takes place by estimating the object position basedon previous data and object existence verification at the predicted location. Prior to carrying out tracking, the motion model must be learned by the system through the use of sample image sequences. A simple way to describe this filter is by describing it as a set of mathematical equations which implement a predictor corrector type estimator, where the optimal reading reduces the estimated error covariance under specific conditions.

Particle filter: This method generates all the models for single variable prior to moving to the next variable. This method is advantageous when variables are dynamically generated andthere are many variables. It also enables for another resampling to be undertaken. One disadvantage of using the Kalman filter is that state variables are assumed to be distributedusing Gaussian methods.

Prediction: Every particle is taken and an additional sample from the motion model, which is added to it. This newly formed cloud of particles will hold the resultant position from the motion model. The prior distribution of particles can be used to approximate the resultant distribution.

Update: Sensor measurements are acquired, and each particle is assigned a specific weight, which is equal to a ratio of sensor measurement observation for the state of a particle. These weights are then subject to normalization. So the total sum to 1.

Re sampling: Selection of new particles takes place to ensure every particle persists relative to its current weight. The highly unlikely particles are not selected at the fringe, whilst the highly likely particles are subject to replication at the cloud's center. This ensures that the high probability regions have a high density. Thus representing the posterior distribution more accurately.

Kernel-based Tracking: This method uses appearance and representations of the object of interest using rectangular or ellipsoidal shapes. Through the motion of each kernel on each frame, it is possible to track an object. The motion of an object can be categorized in different ways including affine transformations, rotation and translation. Several algorithms can be used for this purpose which differs depending on the quantity of object tracking, object representation and object motion estimation method. For example, in the case of real-time applications, it is common to represent objects using geometric shapes. One of the drawbacks of using geometric shapes is that they may not fully encapsulate the target object whilst background elements may also found therein. Different methods can be used for kernel tracking including the mean shift method, CAM Shift, simple template matching, and Kanade-Lucas-Tomasi (KLT) tracking.

Mean shift tracking: This tracking method represents a target through density based appearance models. The algorithm used for this tracking method represents the appearance model using the histogram (texture, color etc). This method uses an iterative approach of tracking, which involves, determining similar pattern distributions located within a sequence of frame. It is possible to improve target representation and accuracy by utilizing the chamfer distance transform method. The chamfer method is also capable of reducing the distance between two color distributions based on the Bhattacharya coefficient.

This method can be characterized by discrete distribution of the sample and localized kernel. Limitation can be partially mitigated using the mean shift algorithm together with the particle filter or Kalman filter. Continuously adaptive mean-shift (CAM Shift) This method is built upon the principles found in mean shift and can be described as a lightweight and efficient tracking algorithm.

The principal difference between mean shift and CAM Shift is the latter uses continuously adaptive probability distributions. The main advantage of this approach is that it permits the probability distribution of a target to be recomputed in every frame. This permits the target appearance, shape and size to change in every frame. On the other hand, mean shift implements static probability distributions, which cannot be updated. However, the main disadvantage of using this method occurs, when there are similarities between the background and the intended targets, which results in search window divergence. The image is separated into different components by setting the region of interest (ROI) for the probability distribution image. Mean shift search window is selected, which defines the target distribution location intended for tracking. The color probability distribution is calculated for the region that centered within the search window.

Kanade-Lucas-Tomasi (KLT): Tracking Shi and Tomsi developed this method which is an extension of the work undertaken by Lucas and Kanade. Due to its effectiveness and widespread use, it has gained an increasing amount of interest by researchers involved in motion tracking disciplines. The reasons why it is so appealing include the tracking algorithm itself, which allows features to be selected in an effective manner. In the first frame, the Harris corners are detected.

Contour tracking: This technique works by iteratively evolving an initial contour based on object location in previous frames to a new location in the current frame. The evolution of the contour is contingent upon object parts in the present frame overlapping the object in theprior frame.

4. Morphological Operations in MATLAB

Morphological Operations is a broad set of image processing operations that process digital images based on their shapes. In a morphological operation, each image pixel is corresponding to the value of other pixel in its neighborhood. By choosing the shape and size of the neighborhood pixel, you can construct a morphological operation that is sensitive to specific shapes in the input image. Morphological operations apply a structuring element called strel in Matlab, to an input image, creating an output image of the same size.

4.1 Types of Morphological operations

Dilation: Dilation adds pixels on the object boundaries.

Erosion: Erosion removes pixels on object boundaries.

Open: The opening operation erodes an image and then dilates the eroded image, using the same structuring element for both operations.

Close: The closing operation dilates an image and then erodes the dilated image, using the same structuring element for both operations.

The number of pixels added or removed from the object in an image depends on the shape and size of the structuring element used to process the image. In the morphological dilation and erosion operations, the state of any given pixel in the output image is determined by applying a rule to the corresponding pixel and its neighbors in the input image. The rule used to process the pixels defines the morphological operation as dilation or erosion.

5. Performance Evaluation

Matlab is a high-performance language for technical computing. It integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation. Typical uses include: Math and computation, Algorithm development, Modeling, simulation, and prototyping, Data

analysis, exploration, and visualization, Scientific and engineering graphics Application development, including Graphical User Interface building. Detection of moving objects and motion-based tracking are important components of many computer vision applications, including activity recognition, traffic monitoring, and automotive safety. The problem of motion-based object tracking can be divided into two parts

- Detecting moving objects in each frame.
- Associating the detections corresponding to the same object over time.

The detection of moving objects uses a background subtraction algorithm based on Gaussian mixture models. Morphological operations are applied to the resulting foreground mask to eliminate noise. Finally, blob analysis detects groups of connected pixels, which are likely to correspond to moving objects.

Create System Objects: Create System objects used for reading the video frames, detecting foreground objects, and displaying results.

Initialize Tracks: The initialize Tracks function creates an array of tracks, where each track is a structure representing a moving object in the video.

Detect Objects: The detect Objects function returns the centroids and the bounding boxes of the detected bjects. It also returns the binary mask, which has the same size as the input frame. Pixels with a value of 1 correspond to the foreground, and pixels with a value of 0 correspond to the background.

Predict New Locations of Existing Tracks: Use the Kalman filter to predict the centroid of each track in the current frame, and update its bounding box accordingly.

It used for block and template matching, the evaluation metrics for finding the best match include mean square error (MSE), mean absolute deviation (MAD), maximum absolute difference (MaxAD), sum of absolute difference (SAD), and sum of squared difference (SSD).

Assign Detections to Tracks: Assigning object detections in the current frame to existing tracks is done by minimizing cost.

Delete Lost Tracks: The delete Lost Tracks function deletes tracks that have been invisible for too many consecutive frames.

Create New Tracks: Create new tracks from unassigned detections. Assume that any unassigned detection is a start of a new track. The display Tracking Results function draws a bounding box and label ID for each track on the video frame and the foreground mask. It then displays the frame and the mask in their respective video players.

6. Results and Discussion

The algorithm of moving object detecting was adopted in an experiment on a short video. The algorithm was implemented on computer by computer software Matlab13.0. The image processing of frame 64 to frame 65 of the video was taken as an example to illustrate its process and some intermediate results. Difference processing was conducted on the two frames, then the gray values of the three components were transformed into plain-gray values After wards, the 5*5 window was used for mean filter, and the image was obtained through threshold decision as shown in the Fig. searched. According to dimensions, the one shadow blocks on the right side of the above figure can be judged as noise, while the two blocks on the left were human in moving. The desired image was finally synthesized with image casing as shown in the Fig.4.

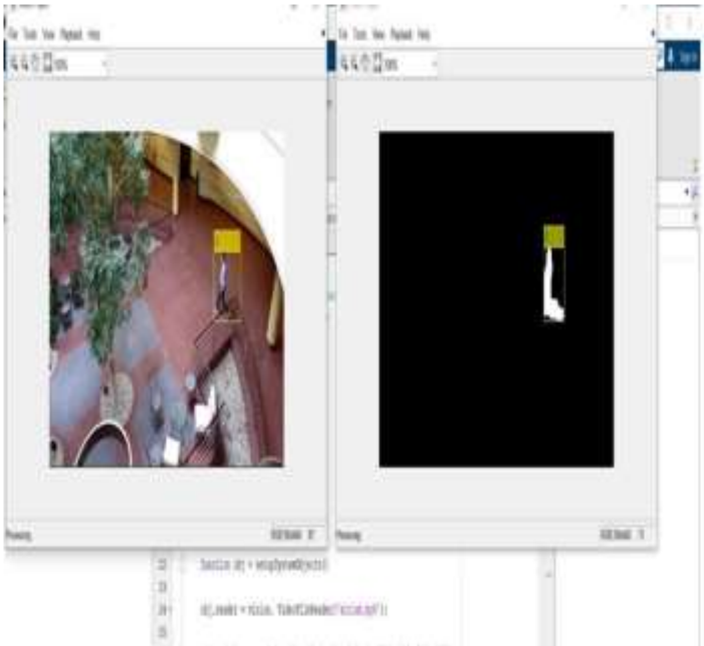

Fig.(a)

Fig.(b).

Fig.4 (a) & (b): Results of Moving Target Detection on Static Background: (A) Original Frame (B) Result Frame

6. Conclusion

It can be seen from analysis and examples that the computer language Matlab has the characteristics of simple programming, easy operation and high processing rate, etc. when used in series of processing of moving object detecting algorithm. The image processing toolkit for language Matlab has powerful functions, with which all commonly used techniques and methods in image processing can be implemented. As a result, the implementation of the algorithm becomes very fast This technology is Reduce shrinkage by catching shoplifters, Deter potential thieves, Monitor cash registers ,Record evidence to prevent bogus accident claims, Identify visitors and employees, Monitor hazardous work areas ,Increase security in and around business premises and parking lots, Meet insurance requirements and used in Video surveillance, Crowd counting, Anomaly detection (i.e. in industries like agriculture, health care), Self-driving cars.

7. Future Scope

Object classifications Better understanding of human motion not only vehicle, including segmentation and tracking of articulated body parts.Improved data logging and retrieval mechanisms to support 24/7 system operationsBetter camera control to enable smooth object tracking at high zoom, incase, video is vibratingVideo stabilization algorithm is required.Acquisition and selection of “best views” with the eventual goal of recognizing individuals in the scene.

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