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Moving Object Detection and Tracking Using MATLAB GUI with ARDUINO

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Abstract: Moving object detection and tracking is one of the security application which has created a great interest for computer vision researchers due to its applications in areas, like video surveillance, traffic monitoring and image recognition. Moving object detection involves identification of an object in consecutive frames where as object tracking is used to monitor the movements with respect to the region of interest. In this research work GUI (Graphical User Interface) is created by using Guide in MATLAB which provides point-and-click control of software applications, eliminating the need to learn a language or type commands in order to run the application. In this paper object detection is performed by using background subtraction algorithm based on Gaussian mixture model that can handle large variations in the background intensity distribution and tracking in videos is performed by using kalman filter which uses a series of measurements observed over time, containing statistical noise and other inaccuracies, and produces estimates of unknown variables that tend to be more precise than those based on a single measurement alone, a bounding box is drawn around the object to track the moving object as the object moves in the video frames, the count value of number objects in every frame is displayed in MATLAB command window. Here MATLAB is interfaced with Arduino board (A microcontroller based board) which is connected with LEDs based on count value number of LEDs will glow. The count value from MATLAB is communicated with Arduino board through serial communication.

Keywords: Moving object detection, Tracking, Guide, MATLAB, LED, Arduino, Serial communication.

I. INTRODUCTION

Visual surveillance is highly identified research area including wide area applications in human activity monitoring, public safety in places like banks, shopping malls, private places etc, automated identification of events of interest, people counting, augmented reality, motion based recognition, autonomous robot navigation and other commercial areas. The rapid advancement in availability of high quality and inexpensive video cameras, high powered computers and increasing demand for video analysis has generated great deal of interest and need of video surveillance [1][2]. However detecting moving objects and tracking from a video is a fundamental and critical task since isolating required object from a video scene is necessary for further process of surveillance as well as differentiating the interested object from other background objects becomes a typical problem.

Videos are actually sequence of images, each of which known as a frame, whenever any video is played our eyes are not able to capture the difference between two frames because of very less time interval between them. The content of two frames are closely related to each other so, for the purpose of object detection there is a need to apply image processing techniques to individual frames. Processing of these frames can be modeled in a hierarchical form using Image processing object detection and tracking methods. First capture a video using a static camera, then extract the frames from that video and apply different processing methods on individual frames. In the next level, we apply the object detection methods like frame differencing, clustering methods and background subtraction on the raw pixels. Then classify the objects according to its features and attributes such as color, edges, corners, size, position, lines, curves and regions. Object detection in videos is used to define the presence of an object in frame sequences and Object tracking is used to monitor spatial and temporal changes during a video sequence, including its features and attributes etc. Kalman filter [3] is essentially a set of mathematical equations that implement a predictor-corrector type estimator that is optimal in the sense that it minimizes the estimated error covariance when some presumed conditions are met. There are numerous applications of Kalman filter, a common application is for guidance, navigation and control of vehicles, particularly aircraft and spacecraft. The basic steps for tracking an object is shown in Fig 1.

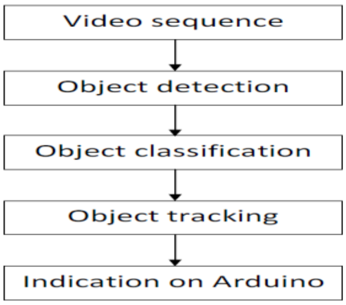

Fig 1Basic steps for tracking an object

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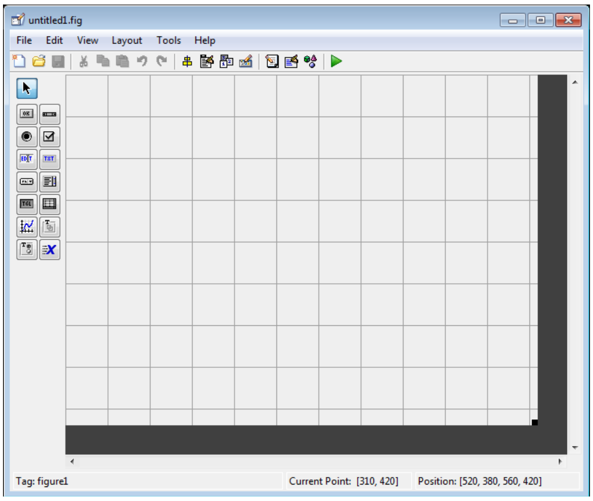
II. RELATED WORK

In MATLAB, Guide [9] is used to create GUI (graphical user interface) applications it is a pictorial interface to a program. A good GUI can make programs easier to use by providing them with a consistent appearance and with intuitive controls like pushbuttons, list boxes, sliders, menus, and so forth. The GUI should behave in an understandable and predictable manner, so that a user knows what to expect when he or she performs an action. For example, when a mouse click occurs on a pushbutton, the GUI should initiate the action described on the label of the button. However, GUIs are harder for the programmer because a GUI-based program must be prepared for mouse clicks (or possibly keyboard input) for any GUI element at any time. Such inputs are known as events, and a program that responds to events is said to be event driven. Working environment of MATLAB Guide is shown in Fig 2.



Tag: figure1 Current Point: [310, 420] Position: [520, 380, 560, 420]

Fig 2 Working environment of MATLAB Guide

Background modeling by Gaussian mixtures is a pixel based process. Let x be a random process representing value of a given pixel in time. A convenient framework to model the probability density function of x is the parametric Gaussian mixture model where the density is composed of sum of Gaussians. Let p(x) denotes the probability density function of a Gaussian mixture comprising K Gaussian densities.

$$p(x) = \sum_{k=1}^{K} \left(w_k N(x; \mu_k, \sigma_k) \right)$$

Where w_k are the weights and $N(x; \mu_k, \sigma_k)$ is the normal density of mean μ_k and covariance matrix $\Sigma k=\sigma_k I$ (I denotes the Identity matrix). The mixture of Gaussian algorithm proposed by Stauffer and Grimson [4], estimates these parameters over time to obtain a robust representation of the background. First, the parameters are initialized with $w_k=w_0$, $\mu_k = \mu_0$, and $\sigma_k=\sigma_0$. If there is a match then.

$$||x-\mu_j|| \,/\, \sigma_j < \Gamma \text{ for some } j \in [1\ldots.k]$$

Where τ (> 0) is some threshold value, then the parameters of the mixture are updated as follows:

$$w_k\ (t) = (1 - \alpha)\, w_k(t - 1) + \alpha\, M_k(t)$$
$$\mu_k\ (t) = (1 - \beta)\, \mu_k\ (t - 1) + \beta x,$$
$$\sigma_k^{\,2}(t) = (1\text{-}\ \beta)\, \sigma_k^{\,2}(t\text{-}1) + \beta\, ||(x\text{-}\mu_k(t)||^2$$

Where $M_k(t)$ is equal to 1 for the matching component j and 0 otherwise. If there is no match, the component with the lowest weight w_k is re-initialized with $w_k=w_0$, $\mu_k = x$ and $\sigma_k=\sigma_0$. The learning rate α is constant and β is defined as

$$\beta = \alpha\, N(x; \mu_k, \sigma_k)$$

Finally, the weights w_k are normalized at each iteration to add up to 1. Stauffer and Grimson proposed to sort the Gaussians by decreasing weight-to-standard-deviation ratio, w_k/σ_k to represent the background. A threshold λ is applied to the cumulative sum of weights to find the set {1…B} of Gaussians modeling the background, defined as:

$$B = \mathrm{argmin}_{K_B} \left(\Sigma_{k=1}^{K_B \le K} w_k > \lambda \right)$$

Intuitively, Gaussians with the highest probability of occurrence, w_k and lowest variability in the distribution, measured by σ_k, indicating a representative mode, the most likely to model the background.

An Optimal Recursive Data Processing Algorithm based technique is Kalman filter[5] which consists of set of mathematical equations, provides an efficient computational (recursive) for estimation of the state of a process in several aspects: it can supports estimations of past state, present state, even future states and it can estimate even when unknown nature of the modeled system. The Kalman filter also estimates a process by using a form of feedback control. The filter is used for estimation of the process state at some time and then obtains feedback in the form of noisy measurements. The equations for Kalman filter fall in two groups: time update equations and measurement update equations. The time update equations for projecting forward (in time) the current state and error covariance estimates to obtain the priori estimation of the next time step. The measurement update equations are responsible for the feedback. Kalman filters always give optimal solutions.

III. METHODOLOGY

Monitoring the motion of an object can be done by identifying and tracking distinct feature of the moving object. Here, a hardware set up is required which can be used as an image acquisition hardware such as camera.

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This camera is connected to a Computer, which captures the video and stores in the memory, this video acts as input to MATLAB. An algorithm for object detection and tracking is written in MATLAB environment. This program detects and tracks moving object, ‘detection’ is performed on images and ‘tracking’ is performed on videos. Once moving object is detected, it is surrounded by bounding box (rectangle box) as the object moves in the video, and a control signal is generated and sent through serial communication to Arduino board. LEDs are connected to Arduino board based on number of objects moving in the frame the same number of LEDs will glow. When object is detected USB to RS232 TTL Converter Adapter Module PL2303HX is used for the serial communication between Arduino board and computer. Proposed experimental model is shown in Fig 3.

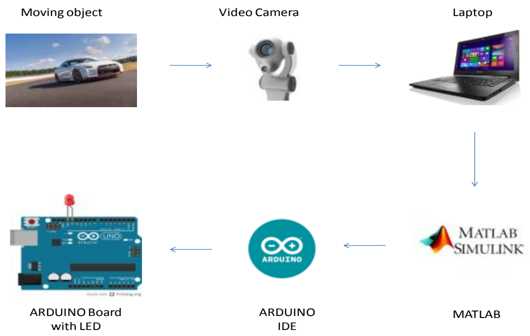

Fig 3 Proposed experimental model

IV. IMPLEMENTATION

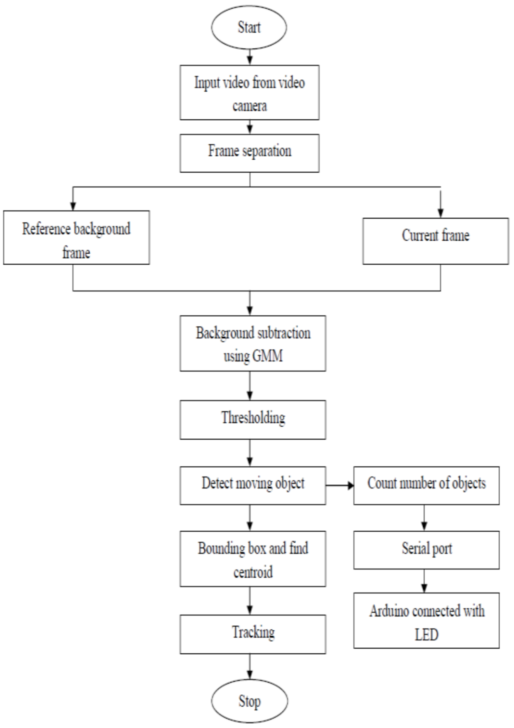
Start
Input video from video camera
Frame separation
Reference background frame
Current frame
Background subtraction using GMM
Thresholding
Detect moving object
Count number of objects
Bounding box and find centroid
Serial port
Arduino connected with LED
Tracking
Stop

Fig 4 Flowchart for detection and tracking

Flowchart of moving object detection and tracking is shown in Fig 4. Detection of object in videos is performed by taking two frames from the video, in one frame only background is present, in another frame foreground object is present then applying Background subtraction based on Gaussian Mixture Model algorithm. This Gaussian Mixture Model is used to eliminate noise from the image. After eliminating noise from the image, an optimum value of threshold must be selected to differentiate between background and foreground. Finally, in the resultant image required object of interest (i.e. foreground object) is detected.

Tracking is performed on videos, we need to first read input video which consists of frames, and then detect moving objects from video. This detect moving object function returns the centroid and the bounding boxes of the detected objects. 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, and then apply morphological operations on the resulting binary mask to remove noisy pixels and to fill the holes in the remaining blobs. We use a Kalman filter to predict the centroid of each track in the current frame, and update its bounding box. In the resultant output video whenever any moving object is detected it is surrounded by a bounding box. The number of objects in a frame is also displayed. Now the data from MATLAB is send to ARDUINO board through serial communication. If an object is detected by serial port LED gets ON, if no object is present LED gets OFF.

V. SIMULATION RESULTS

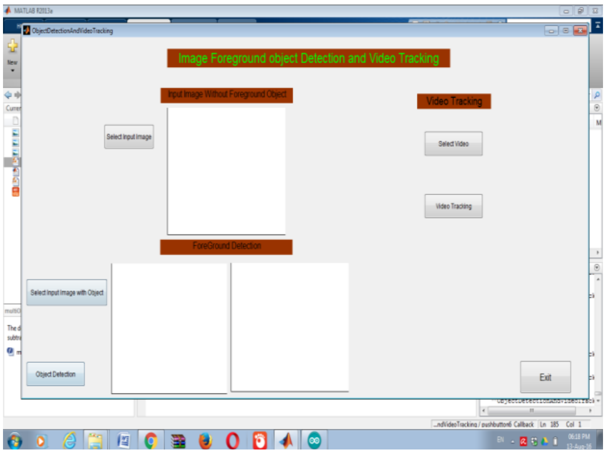
ObjectDetectionAndVideoTracking
Image Foreground object Detection and Video Tracking
Input Image Without Foreground Object
Video Tracking
Select Input Image
Select Video
Video Tracking
ForeGround Detection
Select Input Image with Object
Object Detection
Exit

Fig 5 MATLAB GUI

Fig 5 shows the MATLAB GUI which is created by using MATLAB Guide, three components are used they are Pushbutton, Edit text and Axes. Edit text component is used to write titles with different font size and background colors, Axes is used to display an image in the space provided when we click on the pushbutton. Graphical User Interface development environment of MATLAB is very flexible and simple to select and display an image.

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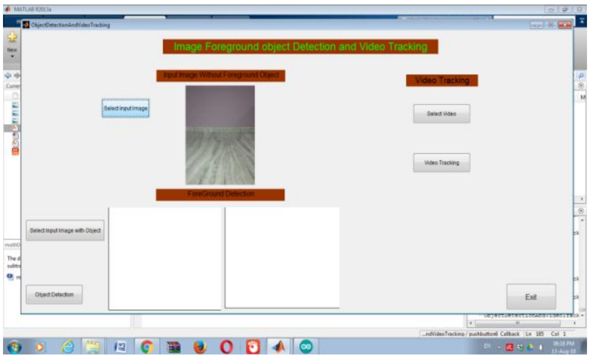


Image Foreground object Detection and Video Tracking
Input Image Without Foreground Object
Video Tracking
Select Input Image
Select Video
Video Tracking
ForeGround Detection
Select Input Image with Object
Object Detection
Exit

Fig 5(a)

When we click on the pushbutton 'select input image' then set of all available images get displayed, from the set of available images we are selecting an image without object as shown in Fig 5(a).

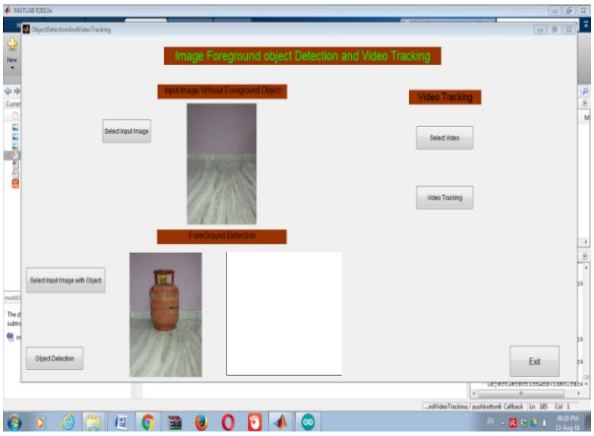


Image Foreground object Detection and Video Tracking
Input Image Without Foreground Object
Video Tracking
Select Input Image
Select Video
Video Tracking
ForeGround Detection
Select Input Image with Object
Object Detection
Exit

Fig 5(b)

When we click on the pushbutton 'select input image with object' then from the set of images we are selecting an image with an object as shown in Fig 5(b).

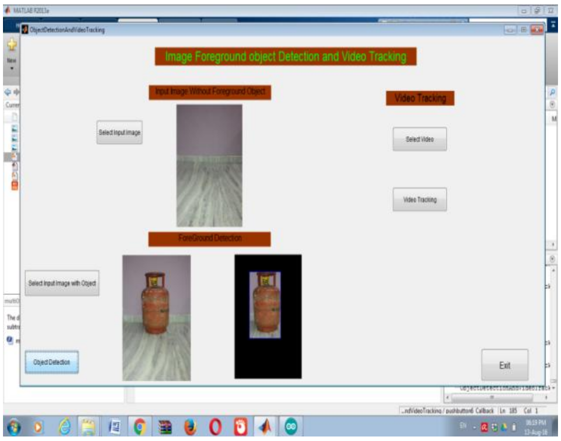


Image Foreground object Detection and Video Tracking
Input Image Without Foreground Object
Video Tracking
Select Input Image
Select Video
Video Tracking
ForeGround Detection
Select Input Image with Object
Object Detection
Exit

Fig 5(c)

When we click on the pushbutton 'object detection' then objects which are present in the image gets highlighted with bounding box, leaving the background black as shown in Fig 5(c).

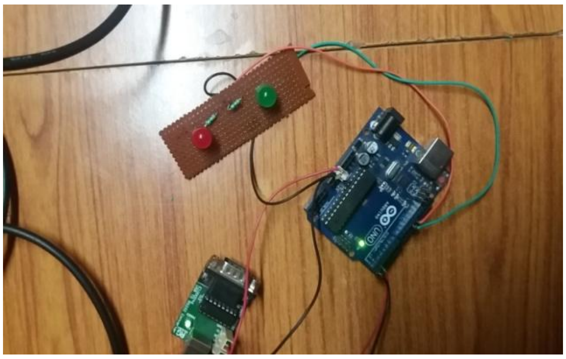
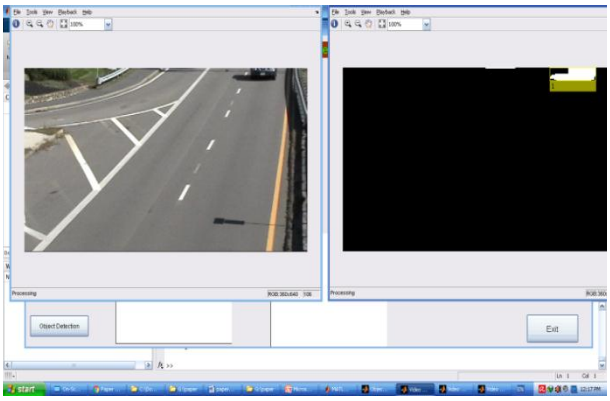


Fig 5(d)

In order to perform tracking operation we need to click on 'video tracking' in GUI, then video starts playing. Fig 5(d) shows a frame number 10 in video in which there are no moving objects, so the number of objects present in the frame is zero. The value zero(0) is sent from MATLAB to Arduino through serial communication. LEDs are connected to pin 11 and pin 12 to Arduino board. Since the count value is zero two LEDs (red, green) are in OFF position as shown in Fig 5(d).



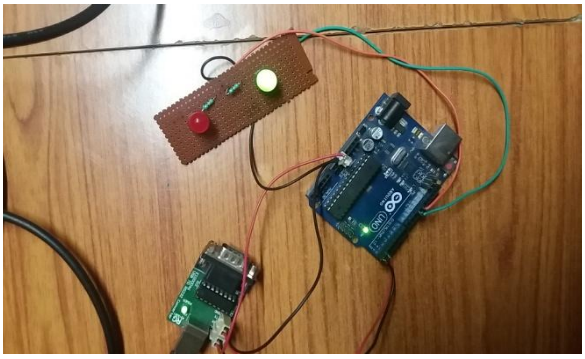


Fig 5(e)

Fig 5(e) shows a frame number 110 in video in which there is one moving object so number of objects present in the frame is one. The value one(1) is sent from MATLAB to Arduino through serial communication. LEDs are connected to pin 11 and pin 12 to Arduino board. Since the count value is one, only one LED (green) is ON shown in Fig 5(e).

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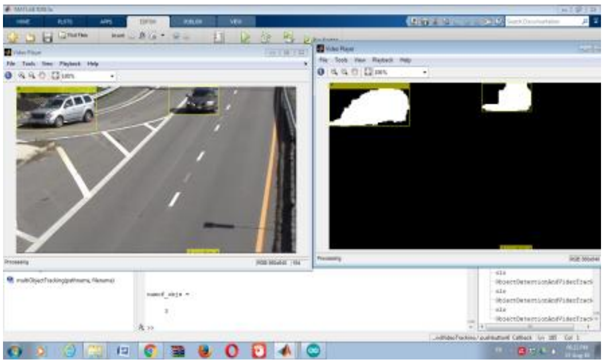


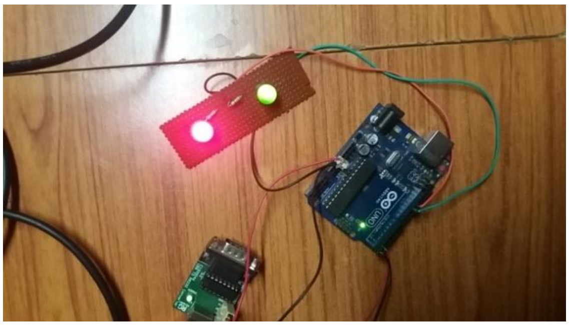
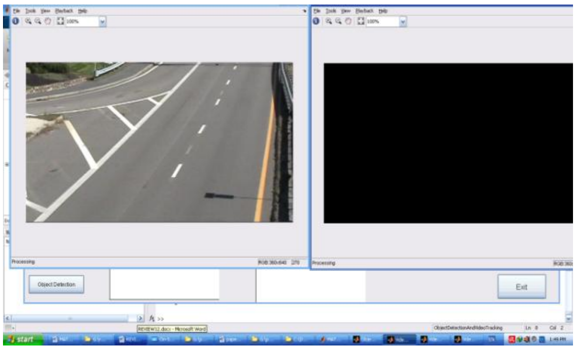


Fig 5(f)

Fig 5(f) shows a frame number 153 in video in which there are two moving object so number of objects present in the frame is two. The value two(2) is sent from MATLAB to Arduino through serial communication. LEDs are connected to pin 11 and pin 12 to Arduino board. Since the count value is two, both LEDs (red, green) are ON shown in Fig 5(f).



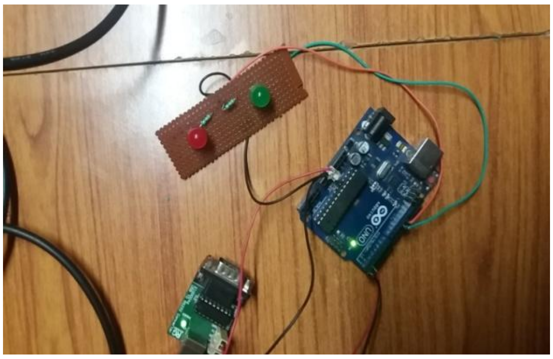


Fig 5(g)

Fig 5(g) shows a frame number 213 in video in which there are no moving object so number of objects present in the frame are zero, both LEDs are OFF as shown in Fig 5(g).

VI. CONCLUSION

This paper proposed a new technique for background subtraction by mixture of Gaussians that can handle large variations in the background intensity distribution and tracking is performed by kalman filter which can predict new locations very efficiently. An intelligent and automatic way of detection and tracking of moving objects is monitored with less human intervention. In future the same technique with robust algorithms can be used with real-time implementation can improve the security in every area and thus reducing security threats.

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