Real Time Embedded Target Detection and Warning System

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Abstract. This paper presents the design and implementation of target detection, tracking and warning system. The proposed framework detects and warns about stationary and moving targets. The function of the implemented frame work is to extract specified targets features from specific offline video file or an online video streaming form a Universal Serial Port (USB) camera. A weighted gain filter is utilized for noise cancelation which efficiently enhances the image quality and then improves the detection process. A series of experiments for stationary and moving targets for an online video streaming are carried out on personal computer to evaluate proposed system efficiency. The proposed system efficiently detected and warned about stationary and moving objects in the presence of object occlusion and utilizing low cost USB camera. The potential of the proposed system lies on its simplicity, minimized cost and the software is designed and implemented using python language to be integrated with the USB camera on an embedded board or personal computer for wide range of applications.
Keywords. Background Subtraction; Color Based Detection; Optical Flow.

1. Introduction

Visual tracking is a very important field in computer vision as it has several vital applications such as video surveillance, human-computer interaction, human and object tracking and identification, intelligent transportation, robotics, video games, traffic flow measurement, vehicle navigation, biometric, industrial automation, security applications and object tracking in smart rooms. Visual tracking can be considered an alternative method for conventional detection, identification and tracking methods such as radars [1, 2].

Object tracking is the process in which the video is analyzed in three stage, the first stage concerned with moving object detection, the second stage concerned with object classification and the last stage concerned with object tracking in the nth frame. Object classification is the process of determining the nature and properties of the object. Then object tracking process tracks the selected object motion parameter such as position, velocity and acceleration. Good tracking can be achieved by continuously updating the detection stage and object parameter as shown in Fig. 1.

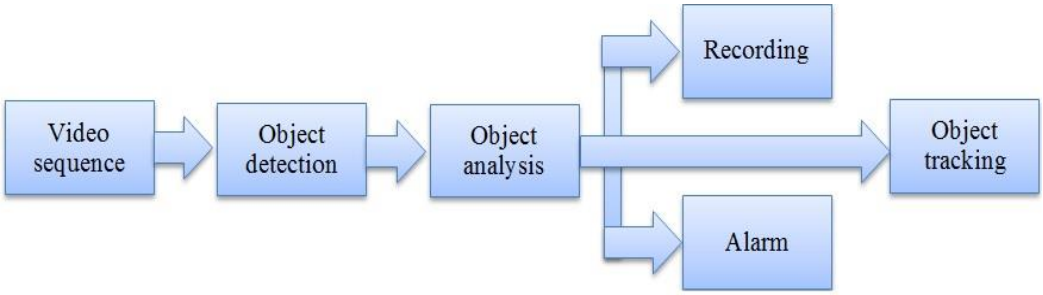


Figure 1. Object tracking procedure

The first step in visual tracking is target detection, that's mean, the identification of objects from video frame and how to cluster pixels of these objects. This can be accomplished by several algorithms such as Background Subtraction (BS), Temporal Frame Difference (TFD), Optical Flow (OF) and Supervised Learning (SL) techniques as shown in Fig. 2. The process of object detection starts with image or video analysis to recognizes its content to determine the object of interest in the image sequence or in each video frame. After locating the targets in the first frame and determine its features the system can determine the object in the next frames simultaneously [3].

Background subtraction is one of the most important detection approaches used for an efficient visual tracking. The content in any frame divided into foreground and background. Foreground is concerned with the moving objects such as cars, people but background contains stationary objects that don't changes from frame to another one. The process starts with determining the stationary part of the image before locating the target which is considered a reference background.

Then just after the target exists the current frame is subtracted from the reference one and so on. The resulting difference image has values below a predefined threshold in the background area of the current image. The area occupied by the object (foreground) has values larger than the threshold. From time to time, the reference background image should be updated to avoid false detection of objects [4-6].

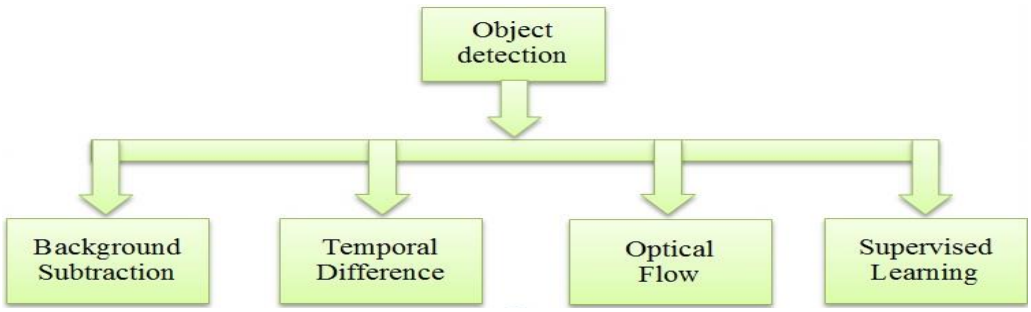


Figure 2. Algorithms for object detection

Background subtraction always shares a drawback of degraded performance when the background changes with time, so temporal frame difference technique is most suitable when the system camera is moving. The process of differencing here is accomplished for two or three consecutive frames, pixel by pixel. In this case the camera motion analysis is computed firstly and then Background subtraction tack place. For a fast moving object the problem of ghost region exists that defined as detecting the overlapping areas of the moving objects and wrongly detects the trailing region of the object [7-9].

Supervised learning is a tool to train a certain classifier to Differentiates between different object views. After training, the decision is made on the specified region to decide that the detected object is a target or not. SL algorithms such as decision trees, boosting, support vector machines and neural network are applied to define targets [10-15].

Optical flow is a common technique to locate moving objects in video frames. Due to the higher detection accuracy of optical flow, it provides the information about object direction and movement in

the form of vectors. It gives a two-dimensional vector field, also called motion field that represents velocities and directions of each point in consecutive image sequences, it is more suitable for multi objective moving analysis in complex scenes with dynamic background. Through optical flow estimation, motion parameters of moving objects can be obtained and at the same time, phenomena of occlusion and overlapping of objects may be avoided as far as possible [16-20].

The core of this paper is to design and implement a standalone, low cost, efficient, real time, and accurately embedded detection system. This system composed of USB We camera, image processing library in laptop to automatically detect and allocate any object then measures the coordinate's errors between the center of object area and the reference point in field of view to be used in different application.

2. Experimental setup

The designed and implemented system is a low cost, simple, rugged, and reliable. This system composed of a low cost USB Web camera, USB hub, Laptop and the associated software program. A software program with python language is designed and implemented in order to detect the stationary and moving object. A USB camera is used in the detection of the stationary and moving targets according to the target features. The video signal picked up by the USB camera which contains the target data, is transferred to a laptop software program (PYTHON) via serial port. The selected USB camera focal lens and light is manually changed to adjust the resolution of the images (this is a facility in the camera that makes it gives a wider range of operation in distance, bad weather and better image). After the detection algorithm finish, the output video is recorded and an alarm is started to warn about the object. Fig. 3 shows the functional block diagram of the experimental system.

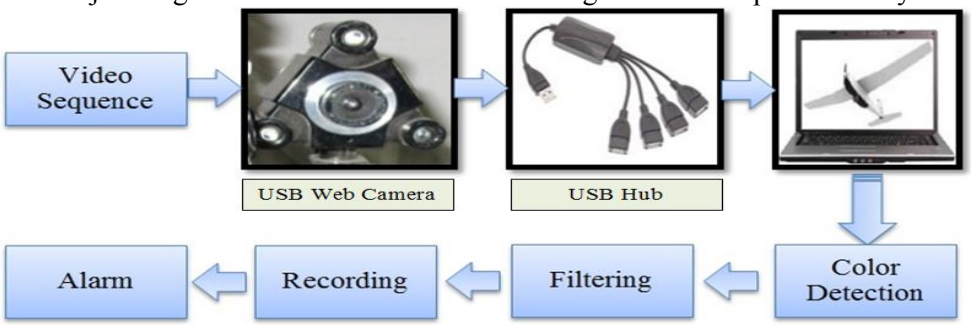
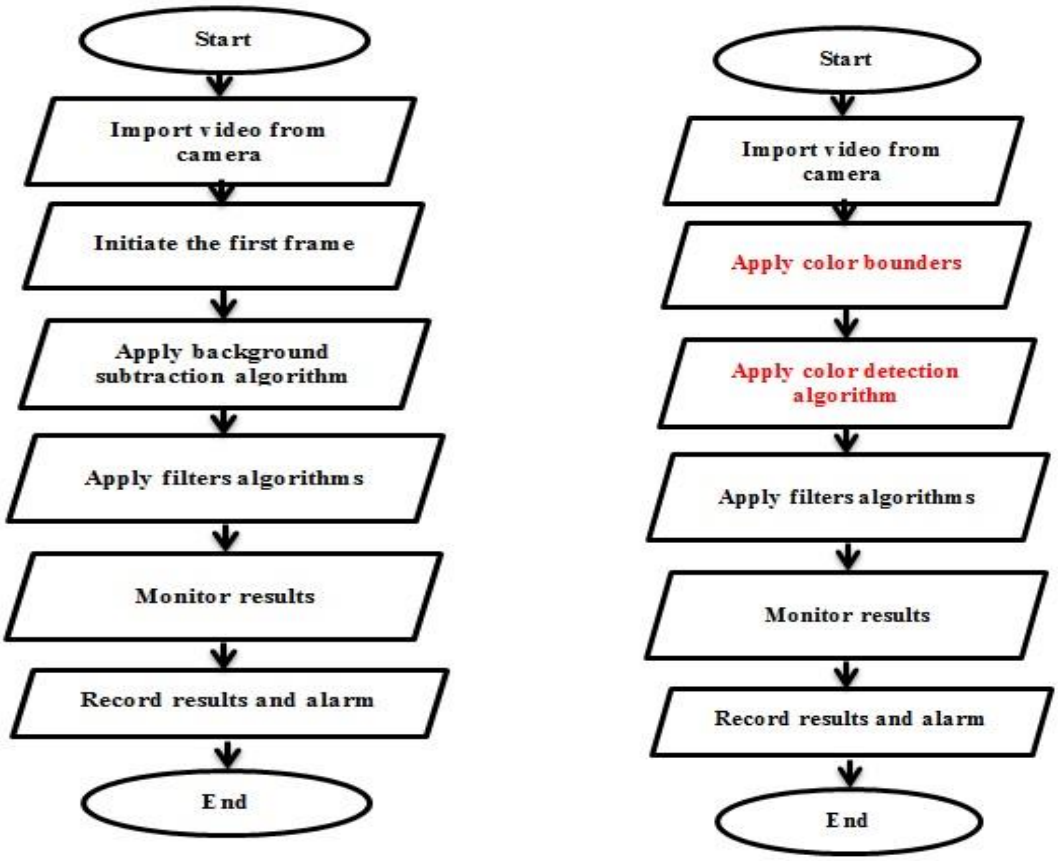


Figure 3. Functional block diagram of the experimental system

A weighted gain filter is used in the algorithm to reject noise in order to enhance the image quality. Noise in the image pixels is eliminated by using the morphological transformation filter in python language. Then foreground object pixel is multiplied by a designed factor to compensate target signal.

Color and background subtraction based detection flowcharts

The proposed procedures for background subtraction and color detection algorithms are summarized by the following flowcharts as shown in Fig. 4 (a), (b).



(a) Background subtraction detection technique (b) Color detection technique

Figure 4. Flowcharts for detection algorithms

The proposed detection algorithms start with importing video from the USB camera or recorded video file. The two algorithms differ from each other in defining the detection procedure techniques. In color based detection technique the upper and lower boundaries of the target color is adjusted in the software algorithm. Target boundaries are calculated according to hue, saturation and value color representation theory. By color boundaries algorithm detects target data and removes all unwanted data from any frames except target data. In background subtraction detection technique the first frame is captured then the nth frame is captured and subtracted from the initial frame. As a result from the subtraction process, frames data are divided into foreground and background. Foreground data identifies moving targets and this process is repeated in each nth frame. After the two algorithms started and the target is sensed, a series of filter is operated to enhance the target signal. The output of filtering is delivered to the recording and warning stages. The program is finished after the target disappears.

3. Results

3.1. Background subtraction based detection technique:

The next test is carried out to a moving object to determine the quality of object detection utilizing the python based programming approach. The background subtraction based detection technique determines the reference frame and then subtract the following frame from it. If there is a moving object inside the frames it will appear as a white photo such as in the case of the yellow object in Fig. 5. This technique is sensitive to the change of the surrounding environment as it is affected by any change in the background. The most important constraint is that there must be a previous knowledge about the background.

3.1.1. Moving targets

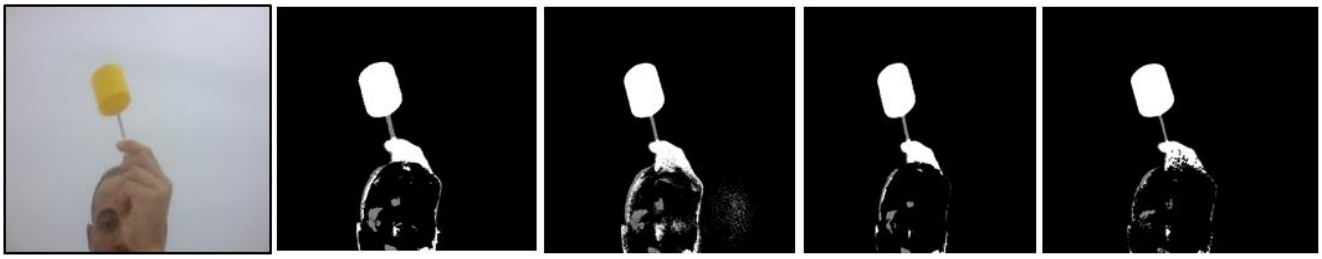


Figure 5. (a) (b) (c) (d) (e)

The output of background subtraction based detection technique for moving target is shown in Fig. 5 (a), (b), (c), (d) and (e). Fig. 5 (a) is the real image of the USB Web camera. Fig. 5 (b), (c), (d) and (e) is a series of filters to enhance the detected object output image. Fig. 5 shows a sufficient result in case of a moving object only and the static background. But when the hand and head of the operator is moved they will appear in the results.

3.1.2. Stationary target

The major drawback in this case is its inability to detect the stationary targets that's mean if the moving target stops and has affixed position, the system stops detecting it as shown in Fig.6.

Figure 6. (a) (b) (c) (d) (e)

The output of background subtraction based detection technique for stationary target is shown in Fig. 6 (a), (b), (c), (d) and (e). Fig. 6 (a) is the real image of the USB Web camera. Fig. 6 (b), (c), (d) and (e) is a series of filters to enhance the detected object output image. There is no target in Fig. 6 (b), (c), (d) and (e) as this technique can't display any target in case if the target stop moving.

3.2. Color based detection technique

Color based detection technique is preferred when only the target is wanted to be appeared. The desired color is initially set in the detecting algorithm before its operation. Fig. 7 shows the result of the similar object in the previous case but with color based detection technique.

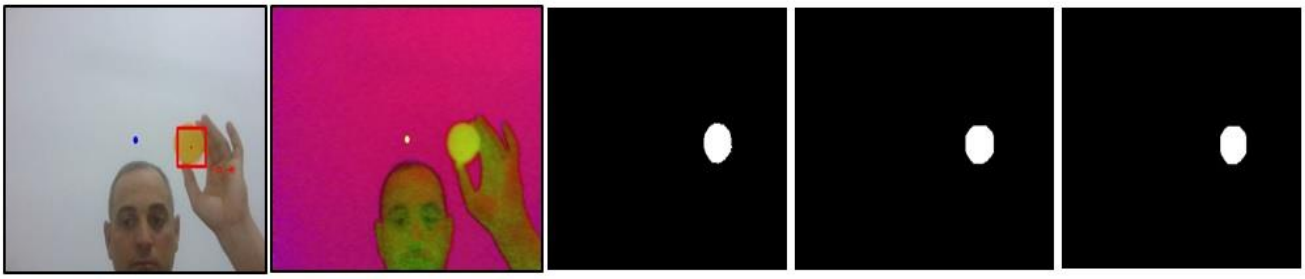


Figure 7. (a) (b) (c) (d) (e)

It is clear from Fig. 7 that only the object is appeared in the results and the surrounding environment is removed. This technique is applicable when the object color is well known and the background doesn't have a similarity of this color. The example of this is a white plane flies in a blue sky. The output of color based detection technique is shown in Fig. 7 (a), (b), (c), (d) and (e). Fig. 7 (a) is the real image of the USB Web camera. Fig. 7 (b), (c), (d) and (e) is a series of filters to enhance the object output image.

4. Conclusion

In this paper, experimental target detection and warning system based on Python programmed algorithm is designed and implemented. This system has the ability to detect stationary and moving targets. Two detection algorithms are utilized for target detection, background subtraction and color based techniques. Three groups of tests are carried out to evaluate the performance of the proposed algorithm and reflect the dependency of the proposed system in visual tracking the targets. The designed system with back ground subtraction algorithm shows acceptable results as it is valid only with moving targets. Color based detection algorithm shows distinctive results because it can be used with stationary and moving targets at the same time. Using hybrid algorithm for target detection, utilizing two or more detection algorithms, is suggested for more efficiency. Also, the designed algorithm can be easily uploaded on embedded board for real time applications.

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