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Review on Video Surveillance using Unmanned Aerial Vehicle

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Abstract: The video surveillance is to hoard and transmit signals captured by the camcorder to a particular place or to multiple locations using video transducers. This is the same for the video cameras as well but the word surveillance is mainly used in places where surveying is needed such as banks, shops, ATMs, etc. Now, aerial monitoring is done by the cameras mounted Unmanned Aerial Vehicle (UAVs) gliding video from a different vantage point in time to a single command and control center. Constant video supervision of remote locales in bucolic areas, dense civic dwellings, and strategic military sites are of paramount interest to law enforcing agencies. The objective of this paper is to determine the importance of aerial vehicles in visual surveillance and also shows various detections and tracking methods for dynamic objects.

Keywords: Video Surveillance, Unmanned Aerial Vehicle, Object Detection, Object Tracking.

I. INTRODUCTION

An unmanned aerial vehicle (UAV) can generally be termed as a drone which is a blimp without a human pilot. The elements of an unmanned aircraft system which include a UAV, a ground-based controller, and a system for communication between the UAV and the ground-based controller. Monitoring is now made possible by using dozens of the camera mounted UAVs such as drones and unmanned gliders streaming video from different vantage points of the location of interest to a single command and control center. It has applications in the field of public safety communications which was recently garnered the attention of the researchers [1][2]. Government authorities use this technology to plan and commit offenses, such as robbery and kidnapping, by businesses to gather intelligence, and by private investigators. The flight of UAV may operate with either under remote control by a human operator or autonomously by onboard computers. UAVs are a real-time system that requires rapid response to changing sensor data. UAV has enormous potential in the public and civil domains. These are particularly useful in applications, where human lives could otherwise be endangered. UAVs can be of different size and various levels of complexity due to the wide range of application, specifically designed according to the mission requirement and with cost consideration. Therefore, it is uncommon to classify the UAV into different types of categories. Some commonly known categories are Micro UAV (MAV), Generic UAV, Tactical UAV, Unmanned Combat Aerial Vehicles (UCAV) and Civil UAV. This paper surveys the importance of aerial vehicles in video surveillance and also shows various detection and tracking methods for dynamic objects.

The operations of UAVs is relatively low in the civilian market but the surveys show that there are growing trends of this system in the civilian market right now. Availability and easily accesses of advance autonomous technology for civilian usage further encouraging a wide range of civilian's UAVs been developed. The lineaments of most civilian used UAVs has a wingspan of not more than 3 meters and its total takeoff weight is more than 6 Kg. It uses a variety of cameras and the mainly used is a petric civilian camera which can cover up to 40 km areas with a time span of 45 minutes. For a good glide, the aerial vehicle must be with a flight endurance of minimum of 20 minutes with a wingspan of maximum 2.5 meters [3].

The object detection and tracking are a difficult task in video surveillance. Object detections performed to check the existence of objects in video and to precisely locate that object whereas object tracking is a process of segmenting a region of interest from a video scene and keeping track of its motion, position and occlusion. Tracking can be done by monitoring the spatial and temporal changes in the object during a video sequence. Video frames are given as input to an object detection system which is followed by

the tracking of objects in video scenes. Finally, actions are performed such as tracking the path of a particular object, study behavior, person identification, etc. The distinct methods for object detection and tracking are mentioned in the next section.

1.1 Object Detection

Detecting motion of an item in a video stream is an essential step in visual surveillance applications. Object detection is to identify an item of interest in the video sequences and to cluster pixels of these items. The object in the video data set can be detected by processes like pre-processing, segmentation, foreground and/or background extraction, feature extraction. Many algorithms have been proposed for moving object detection in recent years. These involve background subtraction, temporal difference, optical flow, and many others. From these algorithms, the most widely used is background subtraction which has many methods such as frame difference, approximate median, Gaussian mixture and Running Gaussian [4]. These comparative studies of various methods are shown in Figure 1.

Methods	Computat-ional Time	Basic Principle	Accuracy	Feedback
Temporal Differencing	High	Pixel wise subtraction of current and background frame	Moderate	Less complex and adaptive to dynamic changes in video. Sensitive to threshold value that determines changes in video frames.
Frame Differencing	Low to Moderate	Current frame is subtracted from background frame	High	Easy to implement and perform well for static background. Requires a background without moving objects.
Optical Flow	High	Uses optical flow distribution characteristics of pixels of objects	Moderate	Complete movement information of object is not produced. Large amount of calculation is required.
Background Subtraction	Approximate Median	Simple subtraction between median frame and test frame	Low to Moderate	Does not require sub sampling of frames to create adequate background model. A buffer with recent pixel values is required for computation.
	Gaussian of Mixture	Based on multimodal distribution	Moderate	Huge memory is not needed. Does not cope with multimodal background.

Fig.1. Comparison of Object Detection Methods.

1.2 Object Tracking

Object tracking is to trail an object (or multiple objects) over a sequence of images. It can be defined as a process of segmenting an object of interest from a video scene and keeping track of its motion, occlusion, orientation, etc. in order to extract the useful information. The aim of an object tracker is to generate the trajectory of an object over time by locating its position in every frame of the video. The comparative study of various methods is shown in Figure 2.

Object tracking method		Algorithm used	Computational time	Accuracy	Comments
Point Tracking	Kalman Filter	Kalman filtering algorithm	Low to Moderate	Moderate	+ Used to track points in noisy images [12] - State variables are normally distributed (gaussian) [12][13]
	Particle Filter	Recursive Bayes filtering	Moderate to High	High	+ Good results for occultation and complex background [14] - Not advisable for real time applications due to big calculations [14][15]
	Multiple Hypothesis tracking	MHT algorithm	Low	Low to moderate	+ Able to deal with entries of new object and exit existing object [18] - Computationally exponential both in time and memory [18]
Kernel Tracking	Simple template matching	Matching region of interest in video	Low to moderate	Low	+ Capable of dealing with partial occlusion [19] - Require equivalent model for each region of interest for each image [19]
	Mean shift method	Expression & location of object; optimal gradient decline	Low	Moderate	+ Can be used for real time applications due to less calculations [7] - Iterations gets into local maximum easily [7]
	Support vector machine	Positive & negative training values	Moderate	Moderate	+ Can handle single image and partial occlusions [25] - Need physical initialization and training [25]
	Layering based tracking	Shape representation using intensity	Moderate	Moderate to high	+Track multiple objects and full occlusion [16] - Require parametric models of each pixel [16]
Silhouette tracking	Contour matching	Gradient Descent Algorithm	Moderate	Moderate to high	+ Object Shape is Implicitly modeled [23] - Requires time for state space estimation [23]
	Shape matching	Hough Transform	High	High	+ Less sensitive to appearance variations - It requires Training [23]

Fig.2. Comparison of Object Tracking Methods

II. Literature Review

This section reveals the various works using the mechanisms mentioned in previous sections. The output of the targets tracking is the basis of many real-world applications including target classification, behavior understanding, etc. It contains a large amount of information of the moving objects in each frame and is the building block for the visual surveillance system [5]. According to the previous information obtained by the particle filter, the possible location of the target in the frame is predicted. Multiscale two-dimensional discrete wavelet is used to characterize the possible target regions. Then, the mean and the variance of the decomposed images are computed. Finally, Principal Component Analysis (PCA) is used to build an effective subspace. By measuring the similarity function between the target and the image regions, tracking can be achieved. In addition, to combat the complex background and occlusion, the characterization vector is updated based on the similarity between the object model and candidate object regions. The strength of this approach is the proposed algorithm, is robust and can significantly improve the speed and accuracy of target tracking.

A unique technique introduced, which was the combination of motion estimation and background subtraction for object tracking using video sequences. It is mainly focused on four schemes such as interpolation, identifying the object, subtracts the background and item selection[6]. Objects are randomly chosen by a user, are tracked using SIFT features and a Kalman filter. Specifically, they concentrated on tracking human, car, or pre-learned objects. The objects are accrued, exploited the learning to successfully track objects even when the objects missing for some frames. Images with higher resolution are used in order to find the location of stationary objects[7].

An automated single camera-based object tracking system was implemented based on frame differencing and dynamic template matching algorithms. This method is efficient for accurate and effective in detecting a single moving object even under bad lighting conditions or occlusions The system has been automated using a pan-tilt setup which is synchronized with the algorithm that is to detect an object, some temporal information computed from a sequence of frames to reduce the amount of false detection. The template matching is a technique in digital image processing for finding small parts of an image which match a template image [8]. Tracker is capable to track abrupt direction and velocity of changing object by combining the Particle Filter and Mean Shift Algorithm. It reduces the number of particles required for robust tracking compared to conventional Particle Filter approach. This approach generates all the models for one variable before moving to the next variable[9].

A robust color tracking method is achieved by resolving a unique color of the target object comparing to the background and updating it when required. The method can perform robustly in tracking a moving object using a robot mounted a camera in a crowded environment. A region of interest (ROI) is defined as a rectangular bounding box that encloses the largest detected moving object. The ROI is then determined by using the maximum width and height of the largest moving object. After the ROI is established, the Hue-Saturation-Value (HSV) of both the ROI and the entire image are analyzed using the ACF (aggregate-channel-feature). HSV performs better in identifying objects under different lighting conditions such as in shadow, shade, and highlights. It does not work well for the outdoor environments [10].

A scheme is proposed for object tracking based on the CamShift approach along with a Kalman filter to predict the location of the item, which offers high processing efficiency [11]. CamShift can automatically adjust the object scale during tracking and tracks objects effectively even with target deformation. The observations show that the framework performs quite well in accuracy and robustness. It can only be used for linear state transitions. Detecting and trailing multiple moving bodies based on discrete wavelet transform and identifying the moving bodies by their color and spatial information is proposed. Only the low-frequency section is used for processing due to the consideration of low computing cost and noise reduction issue [12].

The combination of Approximate Median Filter, Kalman Filter, and Dynamic Template Matching helps in tracking of a single object in a sequence of frames. Either from a live streaming camera or from videos saved previously, a trailing object is detected in each frame with high accuracy and efficiency using Median approximation technique. Kalman filter estimation can be used for tracking the detected object along with a more accurate Template Matching algorithm. Templates are generated dynamically which guarantees any change in object pose which does not be hindered from tracking procedure. Entry and exit of the object are handled efficiently [13].

A quadrotor is used for tracing ground object which uses single monocular cameras as input for feedback control system. The main purpose is to reduce the noise introduced by the visual sensor and also to reduce the errors in object tracking by means of filtering. It loses objects from camera due to either occlusion or connection failure. A monocular is a modified refracting telescope used to enlarge the images of far objects by allowing light through a series of lenses mostly prisms. But the drawback of this system is that it only considers the straight lines and circular motions are supported [14].

III. Conclusion

In this review paper, all the major facets of object detection and tracking are mentioned, and a comparative study had been done on various methods in order to find the efficient algorithm which limits the computational cost and to decrease the time for tracking the objects. Distinguishing objects in a video is quite difficult as a result of the low resolution of images. Background subtraction is the simplest and most widely used method while comparing with the frame difference and optical flow for detecting the moving body. This is because it provides replete information about the objects. This survey paper also describes the concept of object tracking that can be performed using various methods.

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