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A Survey: Unmanned Aerial Vehicle for Road Detection and Tracking

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ABSTRACT: This survey paper basically focuses on different approaches for road detection and tracking for unmanned aerial vehicle videos in urban area. The use of Unmanned aerial vehicle (UAV) natural resource application has increased considerably in recent years due to their greater availability and ability deploy a UAV relatively quickly. A significant change UAV in recent years is that much more data are collected from variety of source . UAV have emerged as an efficient way of improving the performance of transportation systems. Detection and tracking of road in UAV videos play an important role in automatic UAV navigation, traffic monitoring, and ground vehicle tracking, observe conditions on network of roadways. In particular, a graph cut based for detect the road regions during initialize stage and homography based road tracking scheme developed to automatically track road areas. Thus implementation of UAVs in urban areas provides a more efficient of tracking and detection of road conditions and traffic situations in urban areas.

KEYWORDS: Unmanned aerial vehicle (UAV), road detection and tracking, image processing, graph cut algorithm, homography alignment.

I. INTRODUCTION

UAV for surveillance is an active research topic in computer vision that tries to detect, recognize and track objects over a sequence of images and it also makes an attempt to the understand. UAVs may be employed for a wide range of transportation operations and planning applications; traffic monitor, transportation, measurement of typical roadway usage, monitor parking lot utilization.

Road detection and tracking are important and challenging tasks in many computer vision applications such as surveillance, vehicle navigation and autonomous robot navigation. Road detection involves locating objects in the frame of a UAV video sequence. Every tracking method requires an road detection mechanism either in every frame or when the object first appears in the UAV videos.

Road tracking is the process of locating an object or multiple roads over time using a camera. Automatic detection, tracking, and counting of a variable number of objects are crucial tasks for a wide range of applications such as security, surveillance, management of access points, urban planning, traffic control, etc. Conventional traffic data collection relying on fixed infrastructure is only limited to a local region and, thus, it is expensive and labor intensive to monitor traffic activities across broad areas.[1]

In comparison, UAV has advantages, including; there is a low cost to monitor over long distances, it is flexible for flying across broad spatial and temporal scales, and it is capable of carrying various types of sensors to collect abundant data. To collect information for the transportation system, it is important to know where the roads are in UAV videos . Knowledge of road areas can provide users the regions of interest for further navigation, detection, tracking and data collection procedures. Real time is required in many UAV based applications, major target is how to effectively combine both types of information for road detection and tracking in an efficient way. Intuitively, there are two rules to make one integrated framework efficient. First, each component of the framework should be very fast. Second, if one

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component is faster than the others in achieving the same purpose, it would better make use of the fastest component as much as possible.

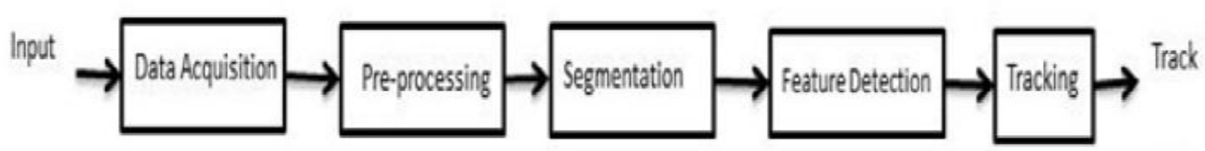

Figure1; Analysis of detection and tracking approach

Figure1, shows basically detect and track system includes five main stages namely data acquisition will take input image data, preprocessing of image, segmentation, feature detection and tracking.
Autonomous unmanned aerial vehicles usually rely on GPS position signal which, combined with inertial measurement unit (IMU) data, provide high-rate and drift-free state estimation suitable for control purposes. Small UAVs are usually equipped with low-performance IMUs due to their limited payload capabilities.

II. LITERATURE SURVEY

Over the past few years, Unmanned Aerial Vehicles (UAV's) image processing has become a popular research topic because of increased data availability. Aerial images can cover a large area in a single frame, which makes them attractive for monitoring and mapping tasks. Therefore, the utilization of UAVs operating in low-altitude for traffic inspection has been a major research interest in the past decade; an introduction to the current trends can be found in this brief survey paper (Lee and Kwak, 2014). Generally speaking, the task can be divided into two essential parts: vehicle detection and vehicle tracking.

A. Road Detection:

Every tracking method requires road detection mechanism either in every fram or when the object first appears in the video. A common approach for road detection is to use information in a single frame. However, some object detection methods make use of the temporal information computed from a sequence of frames to reduce the number of false detections. For object detection, there are several common object detection methods described in [25].

- Point Detectors –
  Point detectors are used to find interesting points in images which have an expressive texture in their respective localities. A desirable quality of an interest point is its invariance to changes in illumination and camera viewpoint. In literature, commonly used interest point detectors include Moravec's detector, Harris detector, KLT detector, SIFT detector.
- Background Subtraction –
  Object detection can be achieved by building are presentation of the scene called the background model and then finding deviations from the model for each incoming frame. Any significant change in an image region from the background model signifies a moving object.

  The pixels constituting the regions undergoing change are marked for further processing. This process is referred to as the background subtraction. There are various methods of background subtraction as discussed in the survey [25] are Frame differencing Region-based or spatial information, Hidden Markov models and Eigen space decomposition.
- Segmentation –
  After preprocessing the next step is segmentation. Segmentation means, separate the objects from the background. The aim of image segmentation algorithms is to partition the image in to perceptually similar regions. Every segmentation algorithm addresses two problems, the criteria for a good partition and the method for achieving efficient partitioning. In the literature survey it has been discussed various segmentation techniques that are relevant to object tracking [25]. They are, Mean shift clustering, and image segmentation using Graph-cuts (Normalized cuts) and Active contours.

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Object detection can be performed by learning different object views automatically from a set of examples by means of supervised learning mechanism.

B. Road Tracking:

The aim of an road tracker is to generate the trajectory of an object over time by locating its position in every frame of the video [25]. But tracking has two definition one is in literally it is locating a moving object or multiple object over a period of time using a camera. Another one in technically tracking is the problem of estimating the trajectory or path of an object in the image plane as it moves around a scene. In the first case, possible object region in every frame is obtained by means of an object detection algorithm, and then the tracker corresponds objects across frames. In the latter case, the object region and correspondence is jointly estimated by iteratively updating object location and region information obtained from previous frames [1].

There are different methods of tracking;

- Point is tracking –
  Tracking can be formulated as the correspondence of detecting objects represented by points across frames. Point tracking can be divided into two broad categories, i.e. Deterministic approach and Statistical approach. Objects detected in consecutive frames are represented by points, and the association of the points is based on the previous object state which can include object position and motion.
- Kernel tracking –
  Performed by computing the motion of the object, represented by a primitive object region, from one frame to the next. Object motion is in the form of parametric motion or the dense flow field computed in subsequent frames. Kernel tracking methods are divided into two subcategories based on the appearance representation used i.e. Template and Density-based Appearance Model and Multi-view appearance model.
- Silhouette Tracking –
  It Provides an accurate shape description of the target objects. The goal of silhouette tracker is to find the object region in each frame by means of an object model generated using the previous frames. Silhouette trackers can be divided into two categories i.e. Shape matching and Contour tracking.
- Feature Selection for Tracking -

It plays a vital role to select a proper feature in tracking. So feature selection is closely related to the object representation. For example, color is used as a feature for histogram based appearance representations, while for contour-based representation, object edges is usually used as features. Generally, many tracking algorithms use a combination of these features.

The details of common visual features are as follows:

i. Color-

Color of an object is influenced by two factors. They are Spectral power distribution of the illuminant and surface reflectance properties of the object. Different color models are RGB, L*u*v and L*a*b used to represent color.

ii. Edges-

Edge detection is used to identify strong changes in image intensities generated by object boundary. Edges are less sensitive to illumination changes compared to color features. Most popular edge detection approach is Canny Edge detector.

iii. Optical Flow-

It is a dense field of displacement vector which defines the translation of each pixel in a region. It is computed using the brightness constraint, which assumes brightness constancy of corresponding pixels in consecutive frames. Optical Flow is commonly used as a feature in motion based segmentation and tracking application.

iv. Texture-

Texture is a measure of the intensity variation of a surface which quantifies properties such as smoothness and regularity. It requires a processing step to generate the descriptors. There are various texture descriptors: Gray-Level Co-occurrence Matrices, loss texture measures, wavelets, and steerable pyramids.

Mostly features are chosen manually by the user depending on the application. The problem of automatic feature selection has received significant attention in the pattern recognition community. Automatic feature selection methods

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can be divided into, Filter Methods and Wrapper Methods. Filter methods try to select the features based on general criteria, whereas Wrapper methods selects the features based on the usefulness of the features in a specific problem domain. Unmanned aerial vehicles (UAVs) have been widely used in many fields, particularly in transportation. The major applications include security surveillance, traffic monitoring, inspection of road construction, and survey of traffic, river, coastline, pipeline, etc. Relevant research can be traced back to the 2000s in the transportation departments of the Ohio [1]. UAV technologies in transportation applications specifically, the objectives of this paper are provide an assessment framework to assess the applicability and cost-effectiveness of UAV and sensing technologies in different transportation applications.

In the literature of road detection and tracking, most approaches use the color (texture) and/or structure (geometry) properties of roads. The combination of road color and boundary information have achieved more robust and accurate results than using only one of them in road detection. Analyze the characteristics of roads in color images of urban and campus environments and algorithm is proposed to extract the candidates of road boundaries and subsequently combining the results of boundary detection with the color information in the image captured, and then present a method to precisely extract the road areas [2]. A popular approach to the problem of road detection is the use of lane markings. Those markings are localized to acquire boundary information that facilitates the road detection process. Methods that rely on lane markings are usually fast and simple, using mainly grayscale images or videos. And second popular method in road detection applications is the use of color or brightness information to segment the road, which is enhanced by some feature extraction process such as edge detection to extract the road boundaries[3]. To improve road detection accuracy and robustness to shadows, many researchers have utilized more complex methods by processing information related to optical flow [6] and stereo vision acquired from camera pairs. In road detection, propose to utilize the GraphCut algorithm (given in discussion) because of its efficiency and powerful segmentation performance in 2-D color images. And in road tracking, aim to track the road border structure between two consecutive frames(detail given in discussion).

In a computer vision society, most developed tracking techniques, such as particle filter ,optical flow ,meanshift are appearance-based methods. Meanshift [22] this paper presents a new approach to the real-time tracking of non-rigid objects based on visual features such as color and/or texture, whose statistical distributions characterize the object of interest. The proposed tracking is appropriate for a large variety of objects with different color/texture patterns, being robust to partial occlusions, clutter, rotation in depth, and changes in camera position. It is a natural application to motion analysis of the mean shift procedure introduced earlier [23]. The mean shift iterations are employed the target candidate that is the most similar to a given target model, with the similarity being expressed by a metric based on the Bhattacharyya coefficient. Road detection and tracking in UAVs, particularly low- and mid-altitude UAVs in this paper, which can be used for autonomous navigation[7], and traffic surveillance and monitoring[8].

A monocular color camera is often equipped in this area, the camera can clearly capture each vehicle on the ground and also has large spatial view on traffic areas. The other research line in UAV-based road detection uses satellite or high-altitude UAVs[13][15], which aims to identify road network, including many junctions and roundabouts from an image. Road extraction in rural areas using stereoscopic aerial images. A strategy based on the dynamic programming algorithm provides a solution to the road extraction problem in the object space. The direct tracing of road centerlines in the object space necessitates mathematical relationships connecting road points in the stereoscopic image spaces and in the object space, enabling integration of radiometric information from the stereoscopic images into the associated energy function. The extraction process begins by first measuring a few seed points in one image of the stereoscopic pair and then transforming these into the object-space reference system. Experimental results show that the proposed method was efficient and usually provided accurate road centerlines[24]. High-resolution cameras are generally utilized in the high-altitude UAV applications. Road detection works use ego-vehicles with onboard cameras for advanced driver assistance systems or UGVs autonomous navigation. A substantial amount of work [3], [14],[16]-[18] have been done in this area. Since the focus of this paper is on road detection and tracking using low-/mid-altitude UAVs, only give a review of the most related works in this area. In general, region color distributions and/or boundary structures are probably the important information utilized for road detection. In [7], they proposed to learn road color distributions using Gaussian mixture models (GMMs) from given sample images, and then determine road pixels in each frame by checking the probabilities of pixels that fit the gaussian mixture models.

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Learning both color and gradient information from images .Gaussian and gamma distributions are used to represent color and gradient models. Vanishing points are calculated by detecting pairs of line segments, and used to rectify the image in order to obtain rectified horizontal scans. Road boundary are then identified by finding large intensity changes in the cross-section profile of each horizontal scan. In [19], in this paper describe the design and evaluation of a system for autonomous vision-based control of an unmanned aerial vehicle (UAV). While various control frameworks exist for UAVs, they typically depend on global positioning system (GPS) data for guidance, and often require constant supervision from a human operator. In this work, examine a control approach for automated flight based on tracking visual cues on the ground. The clustering technique based on prior hue and texture information is used to classify each image pixel into target and background, and then boundary lines are fitted to refine the desired region.

In [20], [21], A histogram-based adaptive threshold algorithm is used to detect possible road regions in an image. A probabilistic hough transform based line segment detection combined with a clustering method is implemented to further extract the road. A simple intensity thresholding technique is used to obtain initial road regions, followed by refinements of local line segment detections, where the assumption is that roads intensities are very different from neighborhood regions and roads can be approximated locally by linear line segments. The proposed algorithm has been extensively tested on desert and urban images obtained using an Unmanned Aerial Vehicle, results indicate that are able to successfully and accurately detect roads.

Overall our objective is a efficient and fast real-time road tracking approach in UAV Videos in urban areas.

III. DISCUSSION

In this paper, follow the aforementioned two rules to make framework fast. Specifically, framework includes two components: road detection and road tracking. In road detection, propose to utilize the GraphCut algorithm [9] because of its efficiency and powerful segmentation performance in 2-D color images.

- Road Detection using Graphcut :

Graphcut can be employed to efficiently solve a wide variety of low-level computer vision problems such as image smoothing, the stereo correspondence problem, and many other computer vision problems that can be formulated in terms of energy minimization Such energy minimization problems can be reduced to instances of the maximum flow problem in a graph. GraphCut based road detection method, where the GMMs are used to model image color distributions, and structure tensors are employed to capture image edge features. In road tracking, propose a fast road tracking approach. There are two facts that spur us to implement road tracking. First, although GraphCut is very efficient, it still cannot achieve a real-time performance when the UAV image resolution is high enough ,and performing road detection frame by frame is not time efficient. Second, road appearance usually does not abruptly change in video; therefore, road tracking can make full use of continuous spatial–temporal information of roads in videos and thus can quickly infer road areas from previous results. In road tracking, we aim to track the road border structure between two consecutive frames. In a computer vision society, most developed tracking techniques, such as meanshift , particle filter [10], and optical flow are appearance-based methods. They are for specific object class, e.g., face, car where objects share common features.

- Homography Alignment Based Road Tracking :

In the field of computer vision, any two images of the same planar surface in space are related by a homography . This has many practical applications, such as image rectification, image registration, or computation of camera motion,rotation and translation between two images. A novel tracking technique based on homography alignment. Homography is a transformation that can be used to align one image plane to another when the moving camera is capturing images of a planar scene. Generally, the road region in application can be well approximated by a plane, and therefore, homography can be applicable to road images. A fast homography estimation approach for road tracking, where the efficiency in homography estimation is attributed to three factors: (1) the FAST corner detector [11] is used to find key points in each road frame. (2) The Kanade–Lucas–Tomasi (KLT) tracker [12] is applied to establish a correspondence between the two sets of FAST corners in two consecutive frames. (3) A context-aware homography estimation approach is given where only the corresponding FAST corners in the road neighbors are used with random sample consensus (RANSAC) estimator, achieve a fast road tracking based on homography alignment.

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Therefore, the use of fast homography-based approach to track most of the road region in each frame can save considerable computation than purely using GraphCut segmentation.

IV. CONCLUSION

This paper is a survey of the current research activities of application of UAVs for road detection and tracking in urban area. It has been generally accepted that UAVs can be very useful and successful for the road networks .
Unmanned vehicles have advantages over manned vehicles as most of the functions and operations can be implemented at a much lower cost, faster and safer. UAVs are programmed off-line and controlled in real-time to navigate and to collect transportation surveillance data.
In this paper, a novel approach for road detection and tracking in UAV videos in urban area, UAVs can communicate through a wireless network with the base station to receive control instructions as well as to send images taken from the UAV. New methods are being developed for data collection and image processing of remotely sensed data.

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