World Journal of Research and Review (WJRR)
ISSN:2455-3956, Volume-8, Issue-5, May 2019 Pages 21-24

A Review on Efficient Road Detection and Aerial Object Localization for Unmanned Aerial Vehicle

Trilok Raj Singh Sisodiya, Vipra Bohara

***Abstract*— An unmanned aerial vehicle (UAV) has many applications in a variety of fields. Detection and tracking of a specific road and vehicles in UAV videos play an important role in automatic UAV navigation, traffic monitoring, and ground–vehicle tracking, and also is very helpful for constructing road networks for modeling and simulation. The paper focuses on the various existing method of detection and tracking and their application for unmanned aerial vehicle navigation. A real-time object localization and tracking strategy from monocular image sequences is developed by effectively integrating the object detection and tracking into a dynamic Kalman model. Compared to existing methods, the proposed approach does not require any manual initialization for tracking, runs much faster than the state-of-the-art trackers of its kind, and achieves competitive tracking performance on a large number of image sequences. Extensive experiments demonstrate the effectiveness and superior performance of the proposed approach.**

***Index Terms*— Kalman filter, road detection, road tracking, unmanned aerial vehicle (UAV)**

I. INTRODUCTION

In the last two decades, we have seen rapid growth in the applications of unmanned aerial vehicles (UAV). In the military, UAVs have been demonstrated to be an effective mobile platform in future combat scenarios. In civil applications, numerous UAV platforms have mushroomed and been applied to surveillance, disaster monitoring and rescue [1], package delivering [2], and aerial photography [3]. In comparison, UAV has advantages, including: low cost to monitor over long distance, 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. 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 equipped with cameras are viewed as a kind of low cost platform that can provide efficient data for intelligent transport systems. With the increasing use of vehicles and their demands on traffic management, this kind of platform becomes more and more popular. Knowledge of road areas can provide users the Image processing is processing of images using mathematical operations by using any form of signal processing for which the input is an image, a series of images, or a video such as a photograph or video frame, the output of images processing may be either an image or parameters related to the image.

Trilok Raj Singh Sisodiya, Research Scholar, Electronics and communication, Yagyavalkya institute of technology, Jaipur, India
Vipra Bohara, Electronics and communication, Yagyavalkya institute of technology, Jaipur, India

A. Vehicle Detection

Recognition of vehicles is crucial for traffic situations recognition. It requires solving the problem of vehicles location and speed determining based on photo or video capture using UAVs. There are two basic approaches to vehicle detection: either detecting moving vehicles either on video or on selected frames irrespective of their speed. The methods of moving vehicles detection are more accurate [4]. For some abnormal situations it is enough to detect only moving vehicles, but to recognize a wide range of abnormal situations (such as congestion (traffic jams), consequences of road accidents, lack of active traffic etc.) it is also important to detect motionless or slowly moving objects.

B. Road Tracking

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 [9], particle filter [10], and optical flow [11], are appearance-based methods. They are for specific object class, e.g., face, car, or pedestrian, where objects share common features. Although some contour-based methods, such as snake [12] or curve fitting [13] approaches, have shown promising road detection and tracking performance for applications to unmanned ground vehicles (UGV), they largely depend on the extracted road border (or markings) and vanishing points of the road, and might not be easily adaptable to UAV applications because the road boundary or markings are usually not salient enough to be detected due to the altitude of UAVs. In addition, these approaches are too computationally complex to be real time.

II. TRADITIONAL METHODS

Road detection and tracking, most approaches use the color (texture) and/or structure (geometry) properties of roads. Among them, the combination of road color and boundary information have achieved more robust and accurate results than using only one of them in road detection, as shown in the work [10], [11]. Therefore, we are in more favor of using both types of information. Because real time is required in many UAV-based applications, our major target is how to effectively combine both types of information for road detection/tracking in an efficient way. Intuitively, there are two rules to make one integrated framework efficient. First, each component of the framework should be fast. Second, if one component is faster than the others in achieving the same purpose it would better make use of the fastest component as much as possible. We follow the aforementioned two rules to make our framework fast. Specifically, our framework includes two components: road detection and road tracking.

In road detection, we propose to utilize the Graph Cut algorithm [12] because of its efficiency and powerful segmentation performance in 2-D color images. In road tracking, we propose a fast road tracking approach. There are two facts that spur us to implement road tracking. First, although Graph Cut is very efficient, it still cannot achieve a real-time performance when the UAV image resolution is high enough (as in our work) 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.

Because of the aforementioned difficulties in adapting existent tracking approaches to track a road in UAV videos, we develop 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 our application can be well approximated by a plane, and therefore, homography can be applicable to our road images. As aforementioned, we aim at making our framework efficient. We thus develop a fast homography estimation approach for road tracking, where the efficiency in homography estimation is attributed to three factors:

1. The FAST corner detector [13] is used to find key points in each road frame.

2. The Kanade–Lucas–Tomasi (KLT) tracker [14] is applied to establisha 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.

Automatic Situation Control of UAVs:
Road traffic control by an operator on the basis of receiving and analysing incoming video information from various observing systems and, in particular, those set up on unmanned aerial vehicles (UAVs). The goal of this monitoring is to increase traffic capacity and safety of the controlled road sections by timely:

- Detection of the movement obstacles in the pre-jam and jam stage, as well as other abnormal situations, including emergencies, and other traffic hindrances.

- Measures aimed at preserving people health and wellbeing, the state protection objects, etc.

- Elimination of abnormal situations consequences.

- Prevention of road accidents and so forth.

Abnormal situations detection and classification are required or an operator to determine the means of consequences elimination for these particular situations. The implementation of these processes implies high information workload for an operator, which can lead to the delays in the required decision-making and cause operator errors.
The research proposes an automation approach to the following processes:

1 Abnormal situations detection.

2 The preliminary classification of abnormal situations.

3 Collecting video data corresponding to a predetermined class, which is necessary for an operator to make decisions.

The observation system, which is responsible for implementing the functions above on board of an UAV, belongs to the artificial vision systems (AVS).

The traffic monitoring organization scenario under consideration comprises four steps:

1. In normal mode, UAV AVS performs video monitoring of a specific road section (patrolling), detecting the vehicles, and estimating their movement characteristics.

2. In case of an abnormal situation, UAV AVS should detect it and notify the operator.

3. After locating the abnormal situation, UAV AVS should perform its preliminary classification
.

4. In accordance with the situation class, UAV AVS collects and transmits the information, which is necessary for an operator to make decisions.

It is obvious that depending on the characteristics and severity of the predicted consequences of abnormal situations, an operator should plan and take a range of appropriate measures, e.g., call emergency services (or road safety service). For this purpose, it is necessary to provide the operator with video information, allowing him to analyze various facts related to this special situation with precision. In some cases, such information cannot be obtained by the UAV while patrolling.

Thus, according to the suggested monitoring scenario, it is necessary to implement situation control of UAV at step 4, which will allow calculating various trajectories depending on the specific road traffic situations (classes of abnormal situations).

Vehicle detection methods based on boundaries detection (such as Canny filter (Canny, 1986) are not always successful, since their use can lead to false activations and combining vehicle adumbrations with shadows, road cracks, road-side, road marking, other vehicles etc. Adumbration can be unstable and certain aspects of a vehicle are impossible to detect. The methods of segmentation and/or marking features on image areas are more appropriate. Below is the vehicle detection scheme for this case:

1. Image scaling and determination of the region of interest (ROI), usually one or more rectangles including the road and the roadside. In this case, navigation data are used.

2. ROI image segmentation.

3. Primary segments filtration (in particular, rejection of very large or very small segments) and combining several adjacent segments, as well as receiving a set of regions.

4. Region filtration.

5. Region descriptors creation.

6. Recognition of vehicles based on region descriptors.

7. Recognition of vehicles based on the velocity fields.

In contrast to fixed camera surveillance, where cameras are mounted around traffic intersections or on buildings, airborne video surveillance has the advantages of higher mobility, faster deployment and larger surveillance scope. Thus, it has attracted a lot of attention from researchers. A key problem within airborne video surveillance is the visual tracking of vehicles. For instance, in some circumstances, it is necessary to analyze the behaviors of vehicles and then to determine whether these behaviors are normal, where the vehicles have to be tracked first [15].

Visual tracking of vehicles [16-22] is considered a fundamental task in computer vision and pattern recognition, which aims to localize moving vehicles that have been detected in previous frames in a video sequence. A typical framework for visual tracking of vehicles includes modules such as moving vehicle detection, vehicle tracking and behavior understanding [23,,15]. There are many existing techniques proposed for each of the modules. For example, optical flow [24,25], background subtraction [16,26], temporal differencing methods [27,28] and pattern classifiers are often used to detect moving vehicles. For vehicle tracking there are mainly four categories of methods: region based tracking, contour based tracking, feature based tracking and model based tracking. Sometimes there is no clear cut between these categories, since algorithms from different categories can be integrated together.

In order to increase the flight safety, the UAV must be able to adequately sense and avoid other aircraft or intruders during its flight. The ability of sense and avoid (SAA) enables UAVs to detect the potential collision threat and make necessary avoidance maneuvers. This technique has attracted lots of attention in recent years. Among all available approaches, vision-based SAA system [3], is becoming more and more attractive since cameras are light-weighted and low-cost, and most importantly, they can provide richer information than other sensors. A successful SAA system should have the capability to automatically detect and track the obstacles. The study of these problems, as a central theme in computer vision, has been active for the past decades and achieved great progress.

Salient object detection in computer vision is interpreted as a process of computing a saliency map in a scene that highlights the visual distinct regions and suppresses the background. Most salient object detection methods rely on the assumption about the properties of objects and background. The most widely used assumption is contrast prior [29], [30], which assumes that the appearance contrasts between the objects and backgrounds are very high. Several recent approaches exploit image background connectivity prior which assumes that background regions are usually connected to the image boundary. However, those methods lack of the capability to utilize the contextual information between consecutive frames in the image sequence. On the other hand, given the position of the object of interest at the first frame, the goal of visual tracking is to estimate the trajectory of the object in every frame of an image sequence. The tracking-by-detection methods have become increasingly popular for real-time applications in visual tracking. The correlation filter-based trackers attract more attention in recent years due to its high-speed performance. However, those conventional tracking methods require manual initialization with the ground truth at the first frame. Moreover, they are sensitive to the initialization variation caused by scales and position errors and would return useless information once failed during tracking.

III. Conclusion

In the paper, various methods or tracking and detection of obstacle or road by UAV have been discussed. The approach is of find the best method for traffic monitoring and obstacle detection for UAV and also for flight safety.

We have proposed an effective and efficient approach for real-time visual object localization and tracking, which can be applied to UAV navigation, such as obstacle sense and avoidance. Our method integrates a fast salient object detector within the Kalman filtering framework. Compared to the state-of-the-art trackers, our approach can not only initialize automatically, it also achieves the fastest speed and better performance than the competing trackers.

References

[1] Amazon, "Amazon prime air," https://www.youtube.com/watch?v=98BIu9dpw HU, 2013.

[2] G. Fasano, D. Accardo, A. E. Tirri, A. Moccia, and E. De L., "Morphological filtering and target tracking for vision-based uas sense and avoid," in Int. Conf. on Unma. Airc. Syst. (ICUAS). IEEE, 2014, pp. 430–440

[3] Y. Lyu, Q. Pan, C. Zhao, Y. Zhang, and J. Hu, "Vision-based uav collision avoidance with 2d dynamic safety envelope," IEEE A & E Systems Magazine, vol. 31, no. 7, pp. 16–26, 2016.

[4] Gavrilov, A., & Lej, S. (2013). The study of methods and algorithms for detecting moving objects in the video stream. Moscow. Bauman Moscow State Technical University. Retrieved from www.sntbul.bmstu.ru/file/out/568767

[5] D. Comaniciu, V. Ramesh, and P. Meer, "Real-time tracking of non-rigid objects using mean shift," in *Proc. IEEE Comput. Vis. Pattern Recog.*, 2000, pp. 142–149.

[6] K. Nummiaro, E. Koller-Meier, and L. Van Gool, "An adaptive colorbased particle filter," *Image Vis. Comput.*, vol. 21, no. 1, pp. 99–110, Jan. 2003.

[7] B. K. P. and B. G. Schunck, "Determining optical flow," *Artif. Intell.*, vol. 17, no. 1, pp. 185–203, Aug. 1981.

[8] Y. Wang, E. K. Teoh, and D. Shen, "Lane detection and tracking using B-Snake," *Image Vis. Comput.*, vol. 22, no. 4, pp. 269–280, Apr. 2004.

[9] Y. Wang, D. Shen, and E. K. Teoh, "Lane detection using spline model," *Pattern Recog. Lett.*, vol. 21, no. 8, pp. 677–689, Jul. 2000.

[10] Y. He, H. Wang, and B. Zhang, "Color-based road detection in urban traffic scenes," *IEEE Trans. Intell. Transp. Syst.*, vol. 5, no. 4, pp. 309–318, Dec. 2004.
[11] G. K. Siogkas and E. S. Dermatas, "Random-walker monocular road detection in adverse conditions using automated spatiotemporal seed selection," *IEEE Trans. Intell. Transp. Syst.*, vol. 14, no. 2, pp. 527–538, Jun. 2013.
[12] Y. Boykov, O. Veksler, and R. Zabih, "Fast approximate energy minimization via graph cuts," *IEEE Trans. Pattern Anal. Mach. Intell.*, vol. 23, no. 11, pp. 1222–1239, Nov. 2001.
[13] E. Rosten and T. Drummond, "Machine learning for high-speed corner detection," in *Proc. Eur. Conf. Comput. Vis.*, 2006, pp. 430–443.
[14] C. Tomasi and T. Kanade, "Detection and tracking of point features," in *School of Computer Science*. Pittsburgh, PA, USA: Carnegie MellonUniv., 1991.
[15] Hu, W., Tan, T., Wang, L., Maybank, S.: A survey on visual surveillance of object motion and behaviors. IEEE Trans. Syst. Mans Cybern. Part C Appl. Rev. **34**(3), 334–352 (2004)
[16] Yilmaz, A., Javed, O., Shah, M.: Object tracking: a survey. ACM Comput. Surv. **38**(4), Article 13 (2006)
[17] Veeraraghavan, H., Masoud, O., Papanikolopoulos, N.: Computer vision algorithms for intersection monitoring. IEEE Trans. Intell. Transp. Syst. **4**(2), 78–89 (2003)
[18] del-Blanco, C.R., Garcıa, N., Salgado, L., Jaureguizar, F.: Object tracking from unstabilized object tracking from unstabilized embedded camera ego motion. In: International Conference on advanced video and signal based surveillance, pp. 400–405. Genova, Italy (2009)
[19] Coifman, B., Beymer, D., McLauchlan, P., Malik, J.: A real-time computer vision system for vehicle tracking and traffic surveillance. Transp. Res. Part C **6**(4), 271–288 (1998)
[20] Ferryman, J., Maybank, S., Worrall, A.: Visual surveillance formoving vehicles. In: Proceedings, IEEE Workshop on Visual surveillance, pp 73–80. Bombay, India (1998)
[21] Ali, S., Reilly, V., Shah, M.: Motion and appearance contexts for tracking and re-acquiring targets in aerial videos. In: IEEE conference on computer vision and pattern recognition, pp. 1–6. Minneapolis,MN (2007)
[22] Beymer, D., McLauchlan, P., Coifman, B., Malik, J.: A real time computer vision system for measuring traffic parameters. In: Proceedings of IEEE conference on computer vision and pattern recognition, pp. 495–501 (1997)
[23] Liu, M.,Wu, C., Zhang, Y.: A review of traffic visual tracking technology. In: International conference on audio, language and image processing, pp. 1016–1020. Shanghai, China (2008) Barron, J., Fleet, D., Beauchemin, S.: Performance of optical flow techniques. Int. J. Comput. Vis. **12**(1), 42–77 (1994)
[24] Tian, T., Shah, M.: Motion estimation and segmentation. Mach. Vis. Appl. **9**(1), 32–42 (1996)
[25] Stauffer, C., Grimson, W.: Adaptive background mixture modelsfor real-time tracking. In: IEEE conference on computer vision and pattern recognition, pp. 246–252. Fort Collins, CO (1999)
[26] Wu, C., Cao, X., Lin, R., Wang, F.: Registration based moving vehicle detection for low-altitude urban traffic surveillance. In: Proceedings of the 8th World Congress on intelligent control and automation, pp. 373–378. Jinan, China (2010)
[27] Lipton, A., Fujiyoshi,H., Patil, R.:Moving target classification andtracking from real time video. In: Proceedings of IEEE workshop applications of computer vision, pp. 8–14 (1998)
[28] Lin, R., Cao, X., Xu, Y., Wu, C.H.Q.: Airborne moving vehicle detection for video surveillance of urban traffic. IEEE conference on intelligent vehicles symposium, pp. 203–208. Xi'an, China (2009)
[29] H. Jiang, J. Wang, Z. Yuan, Y. Wu, N. Zheng, and S. Li, "Salient objectdetection: A discriminative regional feature integration approach," inIEEE Computer Soc. Conf. Computer Vision and Pattern Recognition(CVPR), 2013, pp. 2083–2090.
[30] Z. Jiang and L. Davis, "Submodular salient region detection," in IEEE Computer Soc. Conf. Computer
[31] Hailing Zhou, *Member, IEEE*, Hui Kong, Lei Wei, *Member, IEEE*, Douglas Creighton, *Member, IEEE*, and Saeid Nahavandi, *Senior Member, IEEE* " Efficient Road Detection and Tracking for Unmanned Aerial Vehicle"
[32] Xianbin Cao · Jinhe Lan · Pingkun Yan · Xuelong Li "Vehicle detection and tracking in airborne videos by multi-motion layer analysis " March 2011© Springer-Verlag 2011
[33] Yuanwei Wu, Student Member, IEEE, Yao Sui, Member, IEEE, and Guanghui Wang, Member, IEEE "Vision-based Real-Time Aerial Object Localization and Tracking for UAV Sensing System"