영상과 GPS 정보를 결합한 Follow-me Selfie 드론

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Visual-GPS combined Drone Follow-me Selfie Drone

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Abstract

Follow-me function of drones is new and attractive for selfie drone users, where the drone autonomously follows and capture the user. Currently the products use the difference between GPS's in the drone and user side mobile GCS, but the targeting accuracy is not satisfactory owing to the low accuracy of GPS data, often the order of ten meters. We designed a new follow-me mode algorithm that utilizes the accuracy of visual tracking algorithm and the reliability of GPS-based. The experiment shows that proposed follow-me can capture much accurately the target user in the center of video content than GPS-only methods, and recover the vision algorithm failure quickly in 5-10 seconds.

1. Introduction

Recently micro-UAV, or drones has become popular to hobbyists, and are expected to be used in remote-sensing and delivery service [1]. The most popular application at the present is aerial camera one, and recently 'follow-me' style feature is included in several commercial drones such as Air-dog, Solo, and Hexo+. When flying in follow-me mode, the drone automatically follows its user and captures the activity of the user from a designated distance and angles. Currently this mode is implemented based on GPS data of the drone and user side mobile GCS (ground control station). However, the targeting accuracy is often un-satisfactory due to the low accuracy of GPS sensors [2].

The essential goal of follow me mode is tracking an object, and visual tracking have been studied for more than 2 decades. Recently there have been remarkable progress in visual object tracking algorithm [3]. Also there are several studies [3], [4], [5], [6] on object tracking and following for drone. However, the reliability of any existing visual tracking algorithm does not reach the commercial level reliability for follow-me mode application. For an instance, once the drone loses the target due to occlusion or so, it is very difficult to re-detect it due to large mobility of the target. In this paper, we propose a practical approach that combines the accuracy of visual tracking and reliability of GPS-based tracking.

2. System overview

Our follow-me drone system consists of a drone with Wi-Fi action-cam, GoPro and Android GCS (In Fig. 1). The drone system is built with APM flight stack on Pixhawk [7]. The drone communicates with Android GCS by MAVlink (Micro Air Vehicle Communication) protocol through telemetry. GoPro action-cam [8] captures the video content and stream live video of same but low resolution for image processing. The GoPro camera is mounted on a 2D gimbal. The gimbal uses pan angle itself to stabilize horizontal direction and the drone controls the tilt angle up and down for pointing the camera to the user using a MAVlink command. The GCS get video streaming from GoPro though Wi-Fi connection using UDP. The video data from GoPro are used as input for tracking algorithm.

We has chosen Tracking – Learning – Detection (TLD) [5] for tracking algorithm due to its high performance and ability in notifying target loss, which is seldom available in other tracking algorithms[6]. Combining the target bounding box or lost condition, and GPS data of drone and user, the GCS controls position and attitude of the drone and gimbal so that target user can be centered in the captured video.

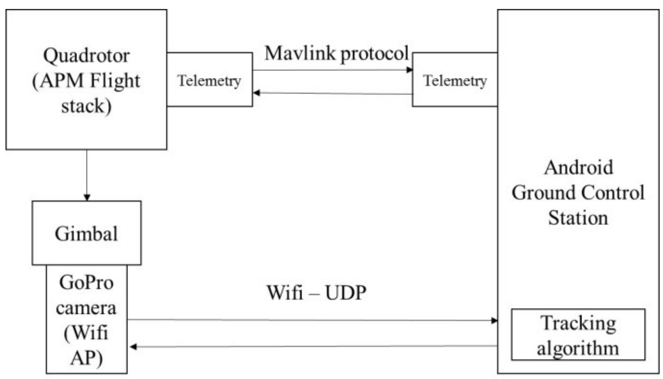

Fig. 1. The design of our drone system

3. Vision – GPS combined algorithm

3.1 Tracking modes

Fig. 2 illustrates two tracking modes and transitions. The visual tracking mode is the desired main tracking mode due to its higher accuracy of target location, but in the case loss of target, the GCS switches to GPS tracking mode. We consider 2 conditions to switch from vision tracking mode to GPS tracking mode:

Case1: The visual tracking reports its failure in tracking for a period (e.g. 5 seconds)

Case 2: The visual tracking report target location bounding box in tracking but the distance between drone and user does not agree with GPS based calculation, which deems that the tracking algorithm is tracking wrong object.

Because TLD algorithm can redetect the target object, tracking mode can be switched back to visual tracking mode by the condition that the object tracking algorithm can get the bounding box of object and the distance between drone and user is nearly equal to the initial distance (current distance < initial + *threshold* meters) between the drone and GCS.

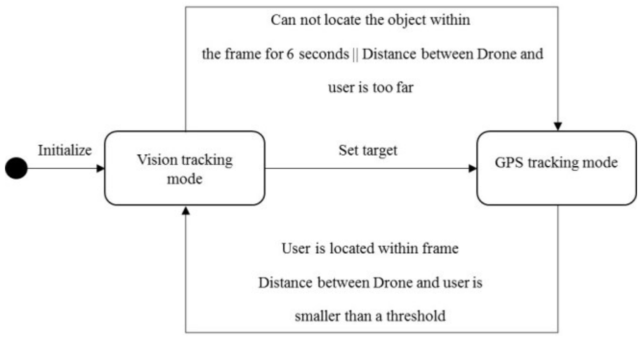

Fig. 2. Visual – GPS combined tracking switching algorithm

The objective of the algorithm is to keep the object as close to the center as possible and keep the distance between the drone and the user as designated.

3.2 GPS tracking mode

The drone control in GPS-based mode uses the longitude, latitude and altitude from GCS and its moving direction, GCS sends positon command to the drone of

$$(lon_{GCS}, lat_{GCS}) + desired\_distance * mvector \quad (1)$$

And the gimbal tilt angle is computed based on GPS values of drone and GCS and altitude of the drone.

3.3 Vision tracking mode

Our drone has 5 control parameters: x, y, altitude, yaw and gimbal angle, whereas the target variables are u, v, and size/distance (3DoF) in image plane. For simplicity of algorithm, we use three control parameters: x, y, gimbal angle only as follows:

- Gimbal angle to keep the user image at the center of image frame, it should be controlled when the center of user's bounding box goes up or down compare to center of the frame
- Y to control the drone go left/right when user's bounding box go to the left or right compare center of the frame
- X to control the drone go forward/backward when the drone is too far or too near the user

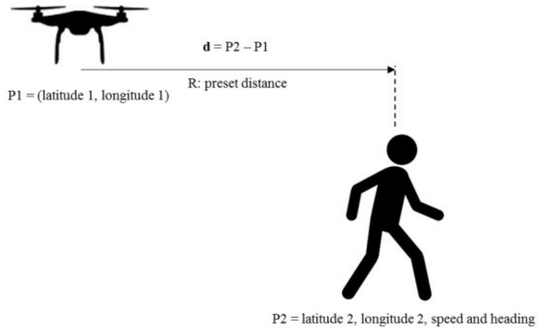

Fig. 3. GPS based Follow-me

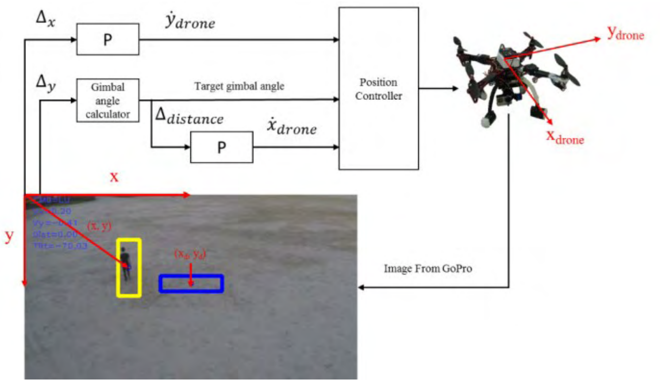

Fig. 4. Control drone algorithm in vision based tracking

We skip the details of control algorithm. For interested reader, please refer [9] or article to be published elsewhere.

4. Experiment result

We performed the following experiments to verify the system.

4.1 vision vs GPS tracking mode performance

First we tested GPS tracking with 2 devices: Samsung Galaxy Grand Max, Asus Memo Pad. Fig. 5 shows the trajectory of vision tracking mode is similar to the user moving trajectory (ground truth). In contrast, the trajectory of GPS tracking mode by Asus Memo Pad was smooth but it is not similar to the user moving trajectory and by Samsung Galaxy Grand Max was not good.

Fig. 5. Trajectory comparison: (*1st*) ground truth, (2nd) vision tracking mode, (*3rd*) GPS tracking mode by Samsung Galaxy

Grand Max, (4^{th}) GPS tracking mode by Asus Memo Pad

We observed the performance of GPS tracking can depends strongly on GPS sensor quality and signal condition. Fig. 6 shows that our visual tracking mode shows much accurate positioning of the target user. Fig. 7 shows the problem with GPS based follow-me, the drone cannot keep the distance well to the user and even sometime cannot locate the target object.

Figure 6. Vision tracking: ROI tracking data

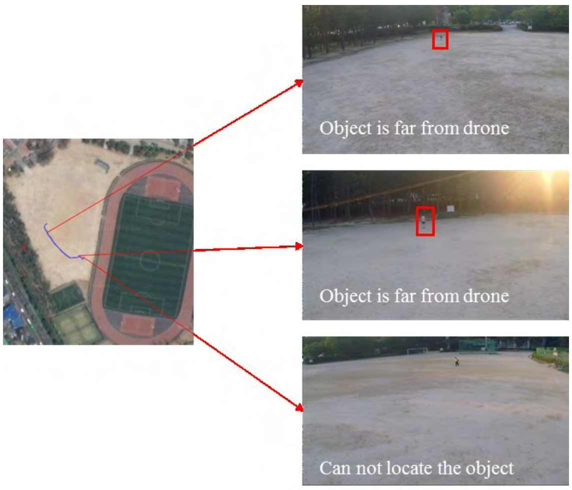

Figure 7. GPS tracking: ROI tracking data

4.2. Vision to/from GPS switching

The scenario in Fig. 8 demonstrate the transition from visual tracking to GPS tracking mode and back from GPS tracking mode to visual tracking mode.

Fig. 8. Vision – GPS – Vision mode switching: 1) Start tracking at Vision tracking mode, 2) the user move out of the range due to vision cannot detect the user, 3) after 30 frame (*our threshold: 6 s*) the drone switch to GPS tracking mode 4) The drone follow user in GPS tracking mode. 5) If the drone can redetect the user => switch to Vision tracking mode

Fig. 9 shows the offset from bounding box of the user to the center of the video frame. From frame 1 to frame 111 is visual tracking mode. The initial distance between drone and user is 9.82 meters. At frame 112, the tracking algorithm lost the object due to object deformation (intentionally). After 30 frames, at frame 142, tracking algorithm changed to GPS tracking mode. The drone follows the user in GPS follow-me mode. At frame 405, the tracking algorithm redetect the user, also the distance between Drone and user is 10.78 smaller than initial distance + *threshold (*5 meters). 2 conditions to switch back from GPS tracking mode to vision tracking mode is satisfied, tracking mode is switched back to vision tracking mode.

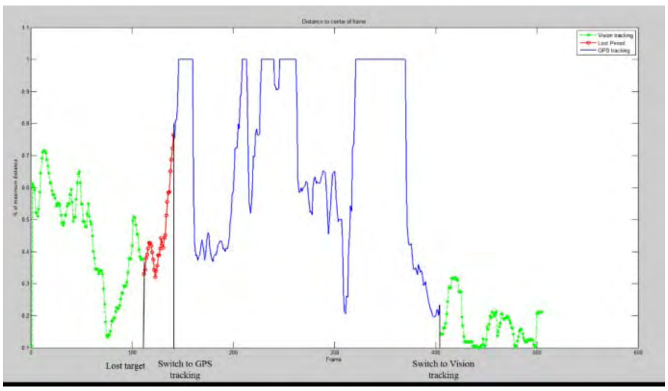

Figure 9. Offset from bounding box to center of frame in Vision – GPS tracking

4.3 Visual tracking algorithm error

The scenario is illustrated in Fig. 10 experiment when the visual algorithm make mistakes, At the beginning, the system started with vision tracking mode, the distance between the drone and the user is 30.26 meters – calculated by the GPS data of the drone and the GCS. After the occlusion with the similar object happens at 79th frame, object tracking algorithm output the similar one is the target object (miss-detect) and keep tracking the wrong object. The real target users keep moving, when the user reaches the position that the distance between the drone and the user is 44.117 meters, the distance is larger than the initial distance (30.26m) + 10 meters (our algorithm's threshold), the algorithm switches to GPS tracking algorithm. The drone files to follow the target user based on GPS data. In Fig. 11, after switching to GPS tracking mode, the distance between the drone and the target object is reduced continuously. In this experiment, the algorithm also tried to switch back to vision tracking algorithm but due to weak Wi-Fi connection (distance is too far), there is no input for visual tracking algorithm.

Fig. 10. Vissual – GPS switching caused by wrong detection: 1) Start tracking at Vision tracking mode. 2) The user appearance is occluded by a similar object. 3) The object tracking algorithm then detect the similar one (miss-detect the target object) 4) The target object keeps moving. At a moment, the distance between the drone and the target object is more than the initial distance + *threshold* (10 meters), our algorithm switches to GPS tracking mode 5) The drone follows user in GPS tracking mode 6) If the drone can redetect the user => switch to Vision tracking mode

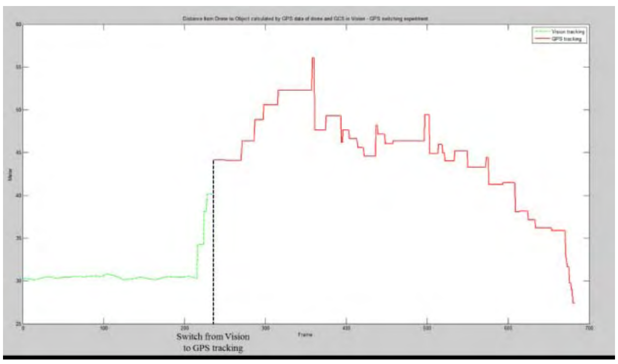

Fig. 11. GPS distance from the Drone and the target object

5. Conclusion

In this paper, we presented and demonstrated visual – GPS combined tracking algorithm for selfie-drone follow-me application, in order to the tracking accuracy limitation of current GPS-based algorithm. GPS is a valuable data for the

We conducted several experiments that revealed how well the proposed Visual – GPS combined tracking algorithm likely to perform. The result shows that the proposed algorithm improves the performance of GPS based Follow-me algorithm.

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Reference

[1] Schneider, David. "Flying selfie bots." IEEE Spectrum 52.1 (2015): 49-51.
[2] The Department of Transportation and the U.S. government. "GPS Civil Monitoring Performance Specification." The 2nd Edition of the document, dated Apr 30, 2009
[3] Wu, Yi, Jongwoo Lim, and Ming-Hsuan Yang. "Online object tracking: A benchmark." Proceedings of the IEEE conference on computer vision and pattern recognition. 2013.
[4] Pestana, J., Sanchez-Lopez, J., Campoy, P., Saripalli, S.: Vision based gps-denied object tracking and following for unmanned aerial vehicles. In: 2013 IEEE International Symposium on Safety, Security, and Rescue Robotics (SSRR), pp. 1–6 (2013).
[5] R. Bart, A. Vykovsk, Any Object Tracking and following by a Flying Drone, 2015 Fourteenth Mexican International Conference on Artificial Intelligence
[6] Kalal, Zdenek, Krystian Mikolajczyk, and Jiri Matas. "Tracking-learning-detection." IEEE transactions on pattern analysis and machine intelligence 34.7 (2012): 1409-1422.
[7] Lim, Hyon, et al. "Build your own quadrotor: Open-source projects on unmanned aerial vehicles." IEEE Robotics & Automation Magazine 19.3 (2012): 33-45.
[8] HERO4 Field of View (FOV) Information [online]. https://gopro.com/help/articles/Question_Answer/HERO4-Field-of-View-FOV-Information
[9] Do T. Tuan, "Visual-GPS combined Target tracking in UAV Autonomous Follow-me mode," master thesis, SeoulTech, Aug. 2017.