Flying Face Engagement: Aligning a UAV to Directly Face a Moving Uninstrumented User

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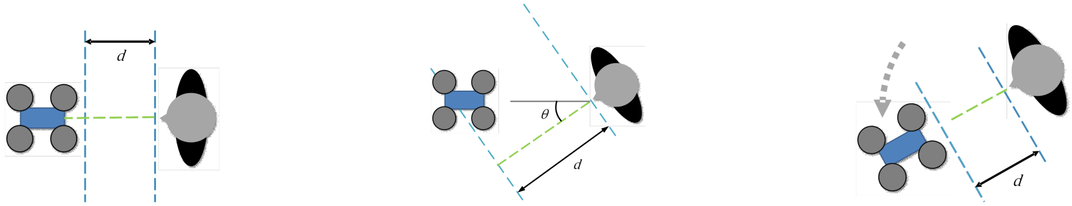

(a) Drone faces user; $d = 1.5m, \theta = 0rad$

(b) User turns and translates; $d \approx 2.0m, \theta \approx 0.7rad$

(c) Drone re-aligns itself so that $d = 1.5m, \theta = 0rad$

***Abstract*— We describe a robot controller that allows an unmanned aerial vehicle (UAV) to continually align itself directly in front of a user at a range of 1-2 meters. Our algorithm employs facial landmark detection to estimate the pose of a single user's face as seen by a camera mounted on the UAV.**

I. INTRODUCTION

We present a robot controller enabling an autonomous drone (UAV) to maintain a fixed distance (1-2 meters) from, and center itself in front of, an uninstrumented user. We use facial landmark detection to perform smooth face pose estimation. PID controllers maintain the distance and orientation of the drone relative to the user. Potential applications include cinematography [1] or pedestrian safety [2]. Previous work on pose estimation includes the use of QR codes [3], and Viola and Jones face detectors combined with a Kalman filter [1]. Unlike previous work [1] which estimates yaw only, our approach yields 6DOF pose estimates and can be used for UAV altitude control as well. Our controller has two stages: *face detection and pose estimation*, and *controller output*[1].

II. ROBOT CONTROLLER

Building on previous work [4], we use the ROS face-detection package to locate the user's face, and then use Dlib's [5] facial landmark detector to compute the 2D position of several salient facial features. Six of these points from the detection and a corresponding set of 3D points from a 3D model of a face are input into a PNP solver. This results in a transformation matrix describing the face pose relative to the camera. However, the result is very noisy without additional filtering, and so we pass each of the six 2D vertices through a low-pass filter before pose estimation.

To stay aligned with the user, the UAV uses three controllers that run independently, similar to [1]. Forwards and backwards motion ensures that the size of the user's face relative to the drone camera remains constant. Lateral motion keeps the user's face centered horizontally in the camera's view. The final controller yaws the drone to face the user. We found that minimizing the error $e = \left(\frac{\theta}{\pi}\right)^2$, where θ is the estimated pose of the user's face, gave much better behaviour than minimizing θ directly. The net effect of these three components is that the drone continually faces the user.

Fig. 1: A screenshot from our video demonstration.

III. CONCLUSION

We have described a system for autonomously aligning a drone in front of a user at close range. A possible extension may be to allow the drone to estimate the pose of the user's head from the rear.

[1]A video demonstration of our system is available at `https://youtu.be/HCqXxOCAFxo`.

REFERENCES

[1] D. Hulens and T. Goedemé, Autonomous flying cameraman with embedded person detection and tracking while applying cinematographic rules, in Proc. CRV 2017, pp. 1-8.

[2] E. Rehder, H. Kloeden, and C. Stiller, Head detection and orientation estimation for pedestrian safety, in Proc. ITSC 2014, pp. 2292-2297.

[3] F. Vasconcelos and N. Vasconcelos, Person-following UAVs, in Proc. WACV 2016, pp. 1-9.

[4] L. Zhang, Optimal robot selection by gaze direction in multi-human multi-robot interaction, in Proc. IROS 2016, pp. 5077-5083.

[5] Dlib Library, *http://dlib.net/*.