Let's Fly! An Analysis of Flying FPV Drones Through an Online Survey

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Abstract
First-person view (FPV) drones provide an immersive flight experience for pilots. In FPV flying, the pilot wears a pair of goggles that display the video feed from the drone in real-time. This allows them to fly the drone as if they were sitting on top of it, thus creating an immersive experience similar to virtual reality and giving the sensation of free flight. Due to these characteristics, FPV flying is becoming popular for recreational purposes (e.g. drone racing). In this study, we conducted an online survey with 515 FPV pilots to explore their preferences and give human-drone interaction researchers an understanding of the FPV community and how pilots interact with the drones. In this paper, we present that the majority of pilots prefer acrobatic flight mode for both racing and freestyle flying. Additionally, we found that FPV flying introduces users to technical fields as the majority of the pilots build their drones, even without having any previous technical background. Lastly, we also present how pilots prefer to interact with remote controllers.

Author Keywords
Drones, drone racing, first-person view, human-drone interaction, human-robot interaction

CCS Concepts
•Human-centered computing → Human computer interaction (HCI); User studies;

Figure 1: FPV goggles.

Figure 2: FPV pilot controlling a drone.

Figure 3: FPV image displayed in goggles.

Introduction

Oftentimes we hear people express their desire to fly; the idea of being able to see and explore the world from the skies has fascinated humans for centuries. The Wright brothers achieved the first successful controlled flight in 1903 [15], and since then, aviation has been evolving and becoming more and more ubiquitous in society. These developments have led to modern unmanned areal vehicles capable of flying autonomously or being remote-controlled, these aircraft are commonly referred to as drones. They are used in a broad range of applications such as photography, natural disaster response [2], agriculture [12], and drone racing [4]. Drone usage is increasing and is expected to continue to do so, the Federal Aviation Administration (FAA) projects that 3.8 million drones will be registered in their database in the United States alone by 2022 [6]. However, drones are remotely operated by a human on the ground and generally lack the ability to provide an immersive experience, which is an important aspect in the remote operation of robots[1].

Recently, a new type of flying drones, known as first person view (FPV), has emerged providing users a more immersive experience while flying. In this modality, the drone is equipped with a front-facing camera which transmits live video to a pair of googles worn by the pilot. This gives the pilot the impression that they are sitting on top of the drone and leads to an immersive experience similar to virtual reality. FPV flying gives the pilot the sensation of free flight, making it especially popular among drone pilots who enjoy flying recreationally. Acrobatic flights (known as freestyle) and racing competitions are common within the FPV community. An example of FPV goggles can be seen in Figure 1, followed by a pilot flying FPV in Figure 2, and a FPV image (displayed in goggles) in Figure 3.

Human-drone interaction research (HDI) can be defined as the study focused on understanding, designing, and evaluating drone systems for use by or with human users[14]. Current human-drone interaction research has focused on developing natural interaction[5], flying user interfaces [7] new control modalities(e.g. brain-controlled drones[11]), social drones[3], and even using drones to provide haptic feedback for virtual reality environments[9]. Drones that broadcast images in real-time have been studied in applications like search and rescue and disaster relief [8]. However, there is a lack of research on the community of pilots who fly FPV recreationally, most likely due to the recency of the field. The ability to fly a drone with the sensation of being onboard allows the creation of new user experiences, interactions, sports, and novelty drone use cases. Therefore, we believe that human-drone interaction (HDI) research could benefit from studying the user interaction with FPV drones.

In this study, we evaluated the FPV drone community and their flight preferences through an online survey completed by 515 FPV pilots. We surveyed FPV pilots to better understand their user experience when flying from a human-drone interaction perspective. Our contributions in this paper are the results of this survey, allowing HDI researchers to evaluate how pilots interact with FPV drones and better understand their user experience. In this survey, we found that the majority of pilots prefer acrobatic flight mode for both racing and freestyle flying. Additionally, we found that FPV flying introduces new users to technical fields as the majority of the pilots build their drones, even without having any previous technical background. Lastly, we also present how pilots prefer to interact with remote controllers.

Study Design & Methodology

To understand the FPV drone community and the experience of flying FPV drones, we conducted an anonymous online survey with 51 questions with 515 FPV pilots. The survey was administered through Qualtrics and data was collected over a period of four months. Participants were required to be at least 18 years old and have experience flying FPV drones. Before completing the survey, participants had to digitally sign an informed consent form. Recruitment was performed solely online and shared on Facebook , Twitch , Discord , Twitter, and Reddit on groups and channels related to FPV drones. The survey collected data regarding (1) pilots' backgrounds (e.g. electronics knowledge) and how they impact their current flight experiences, (2) pilots' flight preferences (e.g. preferred flight modes, remote controller grips), (3) pilots' preferences towards equipment (software and hardware), and (4) how pilots learned how to fly FPV.

Participants

A total of 515 FPV pilots completed the survey. Of these 515 participants, 505 (98.06%) participants are male, 5 (0.97%) are female, and 5 (0.97%) do not identify as either male or female. Additionally, 79 (15.34%) are between the ages of 18 and 24, 133 (25.83%) are between the ages of 25 and 34, 176 (34.17%) are between the ages of 35 and 44, 87 (16.89%) are between the ages of 45 and 54, 34 (6.60%) are between the ages of 55 and 64, and 6 (1.17%) are 65 years of age or older. Of these same participants, 27 (5.24%) are Hispanic or Latino, 439 (85.24%) are Caucasian, 2 (0.39%) are African-American, 2 (0.39%) are Black, 13 (2.52%) are Asian, and 32 (6.21%) are something other than the ethnicity listed above.

Results & Discussion

FPV Racing and Freestyle

First-person view flying is divided into two major categories of flying styles: racing and freestyle. Drone racing is an emerging and competitive sport in which pilots fly FPV drones in complex 3D courses against each other, aiming to be the fastest pilot on the track [4]. Drone racing started as an amateur sport in Australia during the year of 2014 and grew in popularity due to pilots posting racing videos in social media. Drone racing is significantly more complex than flying non-FPV drones, it requires long practice periods and high level of skills [13]. Freestyle flying is a broader concept, as there are no specific rules or competitions for this category. There is no previous formal definition of freestyle flying, therefore, we derive its definition from another extreme activity, freestyle BMX; where its pilots spend their time performing tricks and stunts rather than competing in races[10]. Analogously, we define freestyle flying as the category where pilots fly FPV drones to explore spaces, perform tricks and stunts.

Our analysis of the 515 FPV pilots show that 43.08% of them fly freestyle only, 8.33%, fly only for racing purposes, and 48.57% fly both racing and freestyle. Also, 80% of racing pilots compete at some level, compared to only 13% of freestyle pilots. This is attributable to the more competitive nature of racing sports. Although there are official FPV racing leagues which host competitions, no such leagues exist for freestyle pilots. This is also a plausible explanation for why 15% of racing pilots declared to receive some sort of sponsorship, as these competitions are often televised and draw public attention. In contrast, only 3% of freestyle pilots receive sponsorship. We expect that as FPV sports continue to grow in popularity, official freestyle competitions will emerge and it will become more common for freestyle pilots to receive sponsorship.

Flight Mode	% of Pilots
Position Hold	0.81%
Angle	6.10%
Acrobatic	92.07%
Unknown	0.41%
Other	0.61%
Controller Grip	**% of Pilots**
Thumb	53.46%
Pinch	20.9.%
Hybrid	24.80%
Unknown	0.81%
RC Mode	**% of Pilots**
Mode 1	6.10%
Mode 2	87.40%
Mode 3	0.81%
Mode 4	1.02%
Unknown	4.67%

Table 1: FPV pilots' preferences.

FPV Flight Modes

The characteristics on how a FPV drone responds to pilots input is dependent on the concept of flight modes. This setting can be set on the flight controller and dictates how the pilot can interact with the drone. Non-FPV drones are capable of many flight modes, including assisted and autonomous modes. However, FPV flying aims to provide the pilot with the most control authority over the drone, therefore there are only two main flight modes that are commonly used:

- Angle/Stabilized - This is an auto-stabilization mode in which the pilot input command is translated directly to aircraft attitude, and the aircraft stabilizes itself if the pilot does not send any command. In other words, the movement in the remote controller sticks is translated to the angle in which the drone flies, and the drone levels itself when the sticks are centered in the controller.
- Acro/Rate - In this mode, the aircraft does not stabilize itself, and the stick movement is translated to angular velocity to its correspondent axis. The movement in the remote controller stick dictates how fast the drone spins on each axis, and in the absence of input, the drone will maintain the current angle instead of stabilizing itself.

As shown in Table 1, 474 out of 515 (92%) pilots surveyed selected acro as their main flight mode. Although acro flying has a steep learning curve, it provides the highest degree of freedom for pilots to control their drone. This mode gives the pilot full control over the quad-copter attitude and makes the drone behavior predictable as the flight controller does not try to adjust the drone attitude. Instead, it only ensures that the attitude commanded by the pilot is performed correctly. These characteristics allow racers to better maneuver around obstacles on the track, as well as freestylists to perform stunts that would not be possible in other flight modes.

FPV Remote Controllers

The remote controller (RC) acts as an interface between the pilot and the drone, therefore it is important to understand pilots' preferences when interacting with such devices. There are two factors that influence how FPV pilots interact with the RC itself: the form of grip, and RC mode. There are three main forms of grips in which the pilot holds the controller: thumbs, pinch, and hybrid. These are displayed in Figures 4 5 6 respectively. Table 1 also shows that the majority of pilots (53.46%) prefer to hold their controllers using the "thumb grip", followed by hybrid(24.80%) and pinch (20.9%). However, hybrid and pinch are similar grips, and if they are analyzed together, the gap between their use and thumb grip is not as large. The form of grip can influence the pilot's interaction with the drone in terms of control latency, accuracy, and comfort. Future studies could objectively evaluate how each grip mode impacts the human-drone interaction.

There are also four RC modes that dictate how the RC gimbal sticks are translated to drone commands, as shown in Figure 7. Our results (see Table 1) shows that a large majority of pilots (%87.40) prefer to fly in Mode 2, where the left gimbal translates to throttle and yaw commands, while the right gimbal translates to pitch and roll commands.

STEM Skills Obtained through FPV Drones

FPV drones can be an effective and highly engaging method to introduce STEM education as most FPV drone pilots are also involved in building their systems. In fact, 93.40% of FPV pilots surveyed have built their own drone before. More

Figure 4: Thumbs grip

Figure 5: Pinch grip

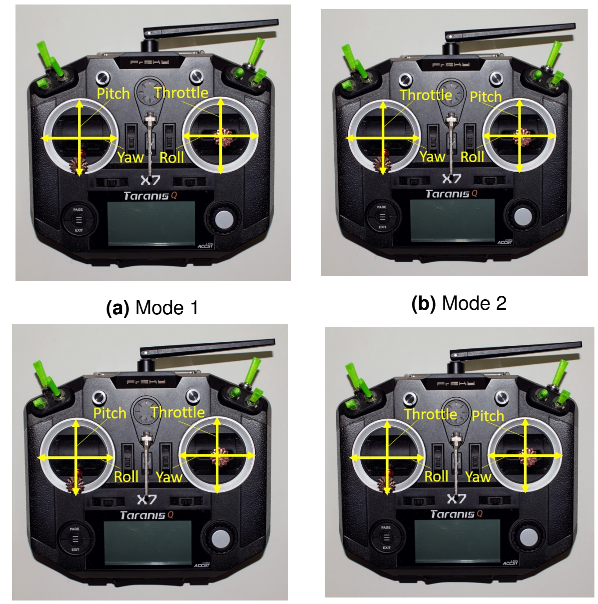
Figure 6: Hybrid grip.

importantly, despite 147 pilots (28.54% of all participants) declaring not having any prior electronics background, all of them have now built at least one drone and 90 (61.22%) out of the 147 have built 5 or more drones. STEM skills which are developed through building FPV drones include both hardware (e.g. soldering, electronics) and software skills (e.g. compiling software and flashing microprocessors). Other skills can also be learned such as flight dynamics and tuning for multi-rotor aerial vehicles, as well as 3D printing. Since the main flight controller software projects are open source, they can also be used to learn software engineering topics. Finally, when pilots were asked to give open tips for beginners, several of them suggested beginners build their own drone so that they know how to fix it when it becomes damaged after eventual crashes.

The above results demonstrate that as users start FPV flying for recreational purposes, they also get introduced to STEM topics. Therefore, we suggest that FPV drone programs (e.g. summer camps, demonstrations, events) can be used to introduce new students to STEM. Our results also demonstrate a small female presence in the FPV community (1% of participants). Therefore, we suggest FPV drone programs dedicated to female participants. Increasing the number of female FPV pilots could be an effective approach to increase STEM diversity.

Conclusion

In summary, FPV flying is growing in popularity as a way to provide a more immersive experience to drone pilots, especially for those who fly recreationally. At the same time, this topic lacks the attention from the HDI research community. To better understand the interaction between FPV pilots and drones, we conducted an online survey with 515 FPV pilots. Responses from the survey indicate that pilots who fly for racing are more likely to compete and re-



(a) Mode 1

(b) Mode 2

(c) Mode 3

(d) Mode4

Figure 7: Types of remote controller modes.

ceive sponsorships as opposed to freestyle pilots. We can also see that the acrobatic flight mode and RC mode 2 are strongly preferred above all other flight modalities, and that the majority of pilots prefer to hold their controllers using the "thumb grip." Furthermore, pilots' survey responses show that the FPV hobby has taught them STEM skills that they did not have previously.

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