Flying Screen with Cooperative Flocking Quad-rotors

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1. Introduction

Recently unmanned air vehicles (UAV's) are being widely used in various fields. The quad-rotor UAV controlled by the rotational speed of the four rotors is considered to be preferable for surveillance and reconnaissance, delivery of goods and some other mission requiring agility and accuracy. Nevertheless, because of such as a concern of infringement of privacy of individuals through the pervasive surveillance and the risk of an accident that may be caused through the drones, the use of drones is easily in daily life [1]. In this paper, we show some cases using quad-rotors in art performance area and address a noble flying screen jump over existing ones.

2. Quad-rotors in art performance

Figure 1 (a) shows that Multi-rotor musicians presented by KMel Robotics in United States can play some flesh songs in ways never seen [2]. Sixteen quad-rotors create music with very high precise movements above instruments. In another performance, Figure 1 (b) show that quad-rotors in swarms with mirrors dance to music with a light reflection system at the Cannes Lions International Festival of Creativity in France [3].

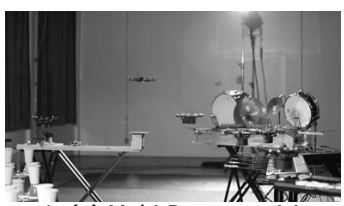

Figure 1. (a) Multi-Rotor musicians

(b) Dance to music with light

Figure 2 (a) shows that Lightpainting with Spaxels prove their skills paint logos and animation into the sky a number of times [4]. The Spaxels, the three dimensional pixels that the Ars Electronica Futurelab in Europe has created based on a quad-rotor technology, has a light source in itself. The Spaxels have flown into the sky and shed a colorful light in Bergen International festival as shown in Figure 2 (b) and Linz [5].

Figure 2. (a) Lightpainting with Spaxels

(b) Lightpainting with Spaxels

3. Flying Screen

Flying screen is also one of such an attempt in art performance. As shown in Figure 3, a lot of quad-rotor, mounting a screen capable of displaying images or video, cooperates with each other to form what shape and perform a fantastic show in narrow areas. To do this, the following techniques as shown in Figure 4 should be required.

As the case of KMel Robotics, an exquisite motion control in Flying Screen must be able to be performed accurately like clockwork on specified operations because quad-rotors in swarms with a small screen should be capable of forming a large flat screen shape or various 3-dimensional shapes in limited space referring to Figure 3. It is expected that the requirement of accuracy will be probably related to the distance between quad-rotors and the spectator.

To build any shape in two- or 3-dimensional, a fine positioning is also required. We may consider a commercial GPS receiver for outdoor positioning, but the receiver can provide only a few meters in accuracy. Even though quad-rotors are far away from the spectators, this accuracy is not surely enough to form a shape. It is expected that Flying

Screen demand that the accuracy of positioning may be tens of centimeters in outdoor environment while especially in indoor environment, a few centimeter in the accuracy of positioning is required in real time with a noble indoor positioning system.

When quad-rotors form curved screen or three-dimensional shape, images presented by quad-rotors might be distorted to observers. For example, if Flying Screen transforms a 3-dimensional scale model of earth from a two-dimensional map, it might represent a distorted map on the Earth's hemispheres because flat images inevitably introduce an increasing amount of distortion. In Flying Screen, whenever the shapes of Flying Screen are changed, the image restoration techniques are expected in real time.

Flying Screen presents an art performance created in one's head. Therefore, it must be able to design and verify contents to be shown in advance with a three-dimensional design tool. This design tool can draw authors' marvelous idea to be performed exactly as they want in 3-dimensional. The tools also have a function that can synchronize movements of quad-rotors, music, and light in time. To control numbers of quad-rotors, the tool can provide flight control information related to quad-rotors' movement to be floated. This flight control information should be downloaded to quad-rotors or used in a flight control system (FCS).

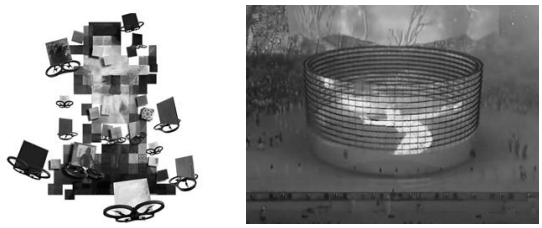

Figure 3. Examples of Flying Screen

Because FCS controls lots of quad-rotors simultaneously, a communication scheme between quad-rotors and FCS should be considered. Even though the scheme can be derived from present wireless communication techniques, e.g., wireless LAN based on IEEE802.11, or Bluetooth and ZigBee based on IEEE802.15, but it depends on an amount of flight control information, a period of delivery and number of quad-rotors to be performed. If Flying Screen displays a move clip stored in its memory, it doesn't matter with communication techniques. However, if Flying Screen should display live video provided by FCS or another quad-rotors, communication techniques are the most important among other things.

When an art performance is presented, quad-rotors in air can avoid obstacles, e.g., birds or objects thrown by whom, flew to them. At first, the quad-rotor can detect these obstacles in time and move to a safe place. If the number of quad-rotors is small, it might be easy to avoid obstacles except detection of obstacles. Even so, if the number of quad-rotors is enormous, it is too hard to calculate ideal ways of quad-rotors to avoid obstacles in a narrow area because other quad-rotors excluding itself might be obstacles to others. To compute optimum paths of quad-rotors to avoid obstacles, lots of quad-rotors should cooperate with each other. As mentioned above, FCS can control each quad-rotor then FCS can help to calculate best paths of quad-rotors, but it is very difficult because detection of obstacles is not easy in remote FCS. In Flying Screen, the quad-rotors can understand and decide autonomously in any circumstance because there are too many quad-rotors - The number of quad-rotors may be almost over a hundred in Flying Screen - in a very narrow area (10m x 10m x 10m).

4. Conclusion

We have proposed that an art performance with the Quadrotor that can provide stable and precise movements. And then we have shown numbers of requirements to fulfill Flying Screen; the exquisite movement control, the fine positioning, the image restoration techniques, the three-dimensional design tool, the flight control system, the noble communication scheme, and the cooperative obstacle avoidance autonomously. We can watch that someday numbers of quad-rotors fly in Olympic opening ceremony and perform magical art show for every human being.

5. References

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