Technology Reports

Drone | Spherical Display | PoV Display

Spherical Drone Display

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The spherical drone display is the world's first airborne spherical display that can display video images in any location while flying. Until now, equipping a drone with a high resolution, large screen display has been problematic due to weight and aerodynamic considerations. This device uses persistence of vision effect display technology and achieves a spherical display that flies stably.

1. Introduction

Magical technologies that create airborne images have long been featured in the world of science fiction, and there have been many studies on how to create these technologies in the real world. These include technologies known as Augmented Reality (AR)*1 to display images created by combining real scenes and computer graphics [1], image projection technologies using floating magnetic spheres [2], and laser technologies that generate plasma in the air [3].

Another of these technologies gaining a lot of attention in recent years involves drones fitted with light sources such as the Light Emitting Diodes (LEDs) to display the airborne images. For example, Intel's "Shooting Star" system uses and simultaneously controls several hundred microdrones fitted with a high luminosity LEDs to produce a giant image floating in the air [4]. Another similar system is the Japanese company MicroAd's SKY MAGIC image display system using drone groups [5]. These technologies are pioneering a new area of image display by establishing new methods to float images in the air. However, these current systems can only have one or several LED lights fitted to each drone, and when flying in groups, the number that can be simultaneously controlled is limited

*1 AR: Technology for superposing digital information on real-world video in such a way that it appears to the user to be an actual part of that scene.

from several tens to hundreds of devices, meaning displays are limited to low resolution images such as simple logos and shapes.

Making use of the flying abilities of drones, NTT DOCOMO has developed a "spherical drone display" by developing improvements to the expressive capabilities of individual drones to make it easier to more freely display images. The spherical drone display enables, for example, dynamic performances that move around in the air at concerts or live venues, and new advertising display medium that flies around venues.

This article describes an overview and the structure of the spherical drone display, issues with implementation, the advantages of this technology, and future improvements.

2. Spherical Drone Display

2.1 Overview

It has been technically difficult to mount high resolution, wide image display screens on drones without adversely affecting their flying abilities. This is because mounting dense arrays of many LEDs or large displays to enable high expressivity can inhibit drone airflow and increase body weight, making it difficult to fly. In other words, with drones, there is a trade-off between flying ability and visual expression capability.

To counter this, NTT DOCOMO has applied a "spherical display technology" to drones to enable high display capabilities without losing flight capabilities. Spherical displays make use of a phenomenon called the persistence of vision (PoV) effect, in which the light and image seem to remain after they have been viewed. Hence, by flashing a light source and moving it, the PoV effect enables images to appear to the viewer along the trajectory of the moving light source. NTT DOCOMO has combined a drone with a spherical display using this PoV display technology to create an omnidirectional spherical drone display, as shown in **Figure 1** (a) and (b) [6].

Figure 1 (a)　A flying spherical drone display

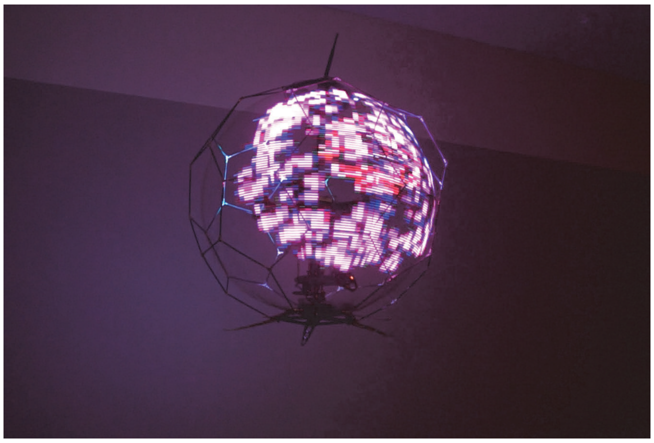

Figure 1 (b)　An image of fireworks displayed on the device

2.2 Device Structure

Figure 2 and **3** show the appearance and structure of the spherical drone display. The device is 88 cm in diameter, and weighs approximately 4.5 kg. The spherical drone display consists of the following three main parts, listed in order from the inside outward.

(1) The drone that produces thrust to enable flight

(2) PoV display to produce the spherical image

(3) A protector for the propellers and LEDs

- The drone is positioned in the middle of the spherical drone display. To fly, the device has four motors attached to 13-inch propellers, and two auxiliary motors and propellers. The four motor-propeller sets are used by the drone for flight, and the two auxiliary motor-propeller sets are used to counter the reaction force of the rotating PoV display, described later. For rigidity and light weight, the frame is mainly made of machined carbon.
- The spherical display consists of eight strips of arc-shaped LED tape*2 encompassing the drone and a mechanism to rotate them. There are 144 LEDs on each tape. The eight LED tapes rotate three times per second, and the LEDs are synchronized to display the spherical image. The LEDs flash 136 times per rotation, which produces an overall resolution of vertical (half-period) 144 x horizontal (one period) 136 pixels. Also, there is a frame rate of 24 fps (frames per second) for the three rotations per second of the eight LED strips.
- The protector is on the outside of the PoV display, to prevent the drone propellers and rotating LEDs from colliding with people or obstacles. The protector must be lightweight and strong, and is designed as a multi-surface shape called a “truncated icosahedron” made of carbon pipes and aluminum joints. The protector

*2 LED tape: An array of LEDs positioned on a tape-like substrate. This technology uses 144 LEDs arranged in a single line on a 1 m long tape.

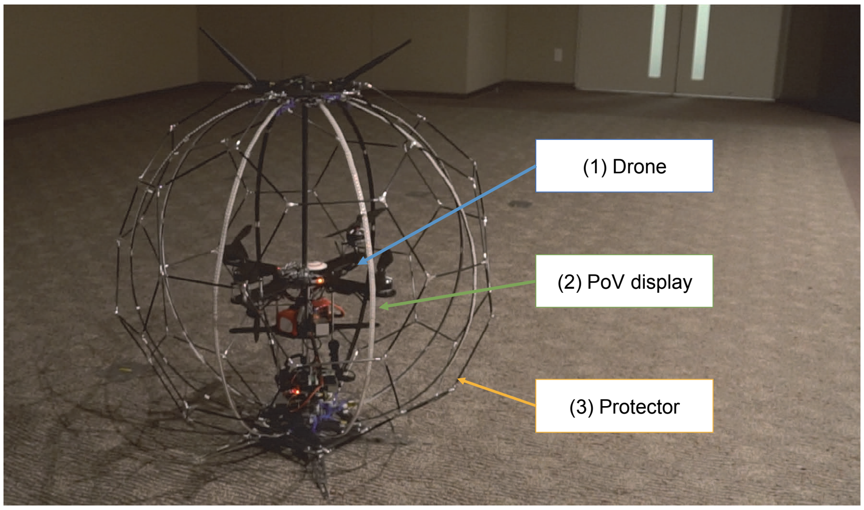

Figure 2　Spherical drone display appearance

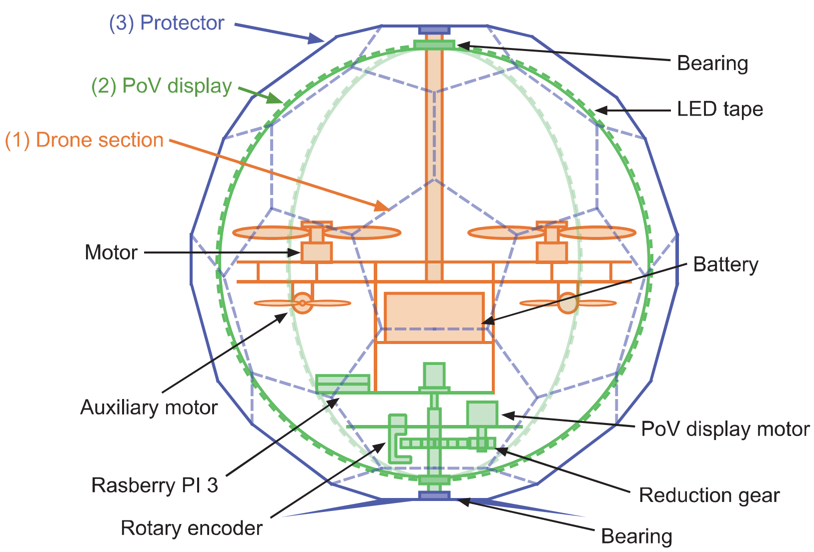

Figure 3　Schematic diagram of spherical drone display structure

does not rotate during display, because the PoV display section rotates independently of the protector and drone sections.

2.3 Challenges and Solutions

Even though the idea behind this technology is simple, there are a range of technical difficulties in its achievement. These difficulties include various challenges such as balancing weight with strength, and high-speed LED control. Particularly, due to the rotation of the LEDs to produce the image, there is a reaction force from the rotation on the drone, which would cause the drone to rotate and make it uncontrollable. To solve this issue, we added two auxiliary motor-propeller sets which rotate to counter the rotational speed of the LEDs to eliminate the reaction force of the PoV display.

2.4 Advantages

The spherical drone display is a combination of the PoV display and a drone, and has the following advantages.

(1) Although the device has a large display surface encompassing the drone and a high apparent resolution, weight and interference with drone airflow are minimized because the actual display surface is only a few narrow arc-shaped LED strips. This has enabled mounting high-resolution, large-screen display on a drone, which was previously difficult.

(2) Because the display is a sphere, it can be viewed from any direction. This is a particularly important advantage because it enables images such as stage presentations or advertising to be delivered in all directions in a venue.

(3) Visibility is high because the drone section does not block the image, and safety is ensured, because all parts including the drone drive mechanism such as motors, propellers and rotating LEDs etc. are housed inside the protector.

(4) High luminosity LED light sources enable an extremely bright display. However, because images are difficult to recognize in direct sunlight etc., users should consider the place and surrounding light conditions when using the device.

(5) PoV displays can display images across the entire surface as shown in Fig. 1 (a), or display partial images as shown in Fig. 1 (b). In addition, because parts that don't display anything appear invisible in dark places, it's possible to use the device to suddenly display images in the air as if they appear from nowhere.

2.5 Future Improvements

There is an issue, because drone mechanisms create a lot of noise when flying. However, it's possible to mask the noise when using the devices at music events such as drone shows, live performance or concerts if the music is sufficiently loud.

The current flying time is dependent on the size of the battery, which is approximately five minutes. Nevertheless, as lighter and lighter batteries are currently under development, flying time is expected to reach approximately 10 to 15 minutes, which will be sufficient to fly for one or two songs during a show or performance.

While the resolution of this display is high compared to drone displays using conventional LEDs, the display is very rough compared to a typical display. This issue could be improved by using specialized boards with higher densities of LEDs, or by positioning adjacent LED tapes so their LEDs are between each other.

3. Conclusion

This article has described a spherical drone display that floats in the air and is capable of omnidirectional image display. This technology featured on several hundred television stations, newspapers and Web news sources etc. both in Japan and around the world since the release of information through the DOCOMO official Web site on April 17, 2017. Then, the device was flown in public for the first time at "NTT ULTRA FUTURE MUSEUM 2017" at the Niconico Chokaigi 2017 held on April 29 - 30. This two-day event attracted several thousand visitors, and the demonstration of the device attracted a great deal of attention. Please follow the link at reference [7] to see a video of this technology. As well as making improvements such as flight time and resolution, we will work towards commercializing the technology for new aerial performances and advertising solutions by incorporating autonomous and group flight technologies.

REFERENCES

[1] T. P. Caudell and D. W. Mizell: "Augmented reality: an application of heads-up display technology to manual manufacturing processes," In Proc. of HICSS '92, Vol.2, pp.659-669, 1992.

[2] J. Lee, R. Post and H. Ishii; "ZeroN: mid-air tangible interaction enabled by computer controlled magnetic levitation," In Proc. of UIST '11. pp.327-336. 2011.

[3] H. Kimura, T. Uchiyama and H. Yoshikawa: "Laser produced 3D display in the air," In Proc. of ACM SIGGRAPH 2006 Emerging technologies, No.20, 2006.

[4] Intel: "Intel-based Drone Technology Pushes Boundaries. (2016)," Retrieved Mar. 2017.
http://www.intel.com/content/www/us/en/technologyinnovation/aerial-technology-overview.html

[5] SKY MAGIC Web site.
https://magic.microad.co.jp/skymagic/

[6] W. Yamada, K. Yamada, H. Manabe and D. Ikeda: "iSphere: Self-Luminus Spherical Drone Display," In Proc. of UIST '17, 2017.

[7] DOCOMO R&D Magazine: "Images in the Air with Drones, Technologies to Stimulate the Five Senses, the Future of Entertainment at Niconico Chokaigi 2017," (In Japanese).
http://style20.jp/rd/article/article_32/