Design of entertainment drone with rotating LED display technology

Anhua You¹*, Jiahao Li², Zifang Xu¹, Wencong Liu¹
¹Nanjing University of Science and Technology, Nanjing, Jiangsu, 210094, China
²Nanjing Foreign Language School Xianlin Campus, Nanjing, Jiangsu, 210046, China
*Corresponding author’s e-mail: youanhua@njust.edu.cn

Abstract. The drone light show is a popular form of performance. This paper designs a new type of entertainment drone with rotating LED display technology. This drone is equipped with a rotating LED display, a single drone can display a complete picture, and has a good display effect. The application of the new entertainment drone can reduce the cost and technical difficulty of the drone light show, and expand the applicable scenarios of the drone light show.

1. Introduction
Drone light show is an emerging form of performance, often used in festival performances or large-scale celebrations[1-2]. Compared with the traditional firework show, the drone show does not produce air pollution, is more environmentally friendly, and can flexibly display text, patterns and even videos. At present, the drone light show is dominated by drone formation performances[3-4]. The formation performance is composed of hundreds of drones equipped with LED lights in the air to form a dot matrix, and the position and LED lights of each drone are controlled by programs. Formation performances require a large number of drones, and the control of drone formations is difficult and prone to malfunctions, which affects the overall performance. The cost of the formation performance is positively related to the number of drones used in the performance. The more complex the images displayed in the light show, the more drones are needed and the higher the cost of the light show. However, a drone usually only carries one LED light for performance, which does not fully utilize the performance of a drone. This paper proposes to apply rotating LED display technology[5] to drone performances and design a new type of entertainment drone. A drone equipped with a rotating LED display can display a complete pattern in the air, and the number of drones required to display a large pattern is lower than that of commonly used solutions. The application of the new entertainment drone can reduce the cost and technical difficulty of the drone light show, and expand the applicable scenarios of the drone light show. The new type of entertainment drone designed in this paper is mainly composed of two parts, a rotating LED display and a quadrotor.

2. Rotating LED display
The drone used in drone light show usually carries only one LED light, forms a pixel of the overall pattern in the performance. The application of LED display makes a drone to display more content. Ordinary LED displays are composed of semiconductor LED dot matrix, and display different pictures by controlling the colour of LED lights in different positions on the screen. The rotating LED display is a display device that works according to the principle of persistence of vision. Persistence of vision
traditionally refers to the optical illusion, which occurs when visual perception of an object does not cease for some time, after the rays of light proceeding from it have ceased to enter the eye.

Figure 1. Rotating LED display structure

The rotating LED display is mainly composed of two parts: the base and the LED dot matrix. The motor on the base makes the LED dot matrix to rotate at a high speed, and the single-chip microcomputer controls the LED light to light up in an appropriate position. The persistence of vision phenomenon causes the brain to visually overlap and see a complete picture.

Ordinary LED displays are opaque. In the application scenario of the drone light show, the opaque display will block the background of the performance scene and negatively affect the visual effect of the drone light show. Especially in the case of displaying a three-dimensional picture, the display effect of the rotating LED display is better than that of the ordinary LED display, and the picture is more three-dimensional and realistic, giving people an immersive feeling[6]. And the viewing angle of the rotating LED display is larger than that of the ordinary LED display, allowing more audiences to see the performance under the same conditions. The weight of the display will have an important impact on the flight time of the drone. The greater the weight of the display is, the shorter the flight time of the drone is. Because of the difference in principle and structure, to display the same number of pixels, the number of LED lights required to rotating LED display is much lower than that of the ordinary LED display. Therefore, under the same conditions, the weight of the rotating LED display is smaller, and the power consumption is lower.

After analysing the above situation, this article chose a rotating LED display with a diameter of 43cm. The display is equipped with 224 LED lights and weighs about 200g. The rotating LED display can play the video stored in the SD card, and can also get the picture on the player in real time via WiFi. Multiple rotating LED displays can be spliced into a larger display to display more content. The physical image and display effect of the rotating LED display are shown in the figure.

Figure 2. Rotating LED display and display effect

3. Design and realization of the quadrotor
The drone is the carrier of the display, and a stable and reliable drone is the prerequisite for the performance. As one of the multi-rotor aircraft, the quadrotor has the advantages of small size, simple structure, flexible operation, vertical take-off and landing[7]. In this paper, a quadrotor is selected as the carrier. The quadrotor is mainly composed of a flight platform and a flight control system.

As the basis of drone flight, the flying platform of the quadrotor needs to have the characteristics of light weight and high strength. Carbon fibre material is a light-weight and strong material, often used in drones. We designed and processed the frame made of carbon fibre materials to meet the above requirements. The structure of the entire drone platform is basically symmetrical, and the centre of gravity is on its geometric centre. The battery provides power for the flight control system and drive
system. In order to improve the load capacity of the quadrotor flight platform, a lithium polymer battery with high energy density and high power is selected; the brushless DC motor drives the propeller to rotate and provides lift for the drone. The structure of the drone is shown in the figure 3, and the wheelbase of the quadrotor is 650mm.

![Quadrotor flying platform](image3.jpg)

The flight control system collects data from various sensors in real time and calculates the attitude, position, speed and other information of the drone. According to the control instructions, it calculates the control instructions of the motor, and converts the control instructions into PWM signals to drive the motor to rotate, and finally achieve flying manoeuvres. Pixhawk is an open-source flight control project that aims to provide a high-end autopilot with low cost, good stability, high safety, and multiple functions for academic researchers, drone enthusiasts and industrial teams. In this paper, Pixhawk is used as the flight control of the quadrotor. The drone equipped with GPS positioning modules can complete automatic flight missions in outdoor environments.

The positioning accuracy of ordinary GPS is at the meter level, which does not meet the position accuracy requirements of the drone light show. Real-time kinematic positioning (RTK) is the application of surveying to correct for common errors in current satellite navigation (GNSS) systems. It uses measurements of the phase of the signal's carrier wave in addition to the information content of the signal and relies on a single reference station or interpolated virtual station to provide real-time corrections, providing up to centimetre-level accuracy. In order to achieve high-precision position control of the quadrotor, the RTK positioning system[8] is used in this article. The base station is placed in an open area to continuously observe GPS satellites, and the observation data and base station information are sent to the rover in real time through radio transmission equipment. The rover calculates its position in real time based on its own observation data and data from base station. The high-precision position data of the rover is transmitted to Pixhawk through the serial port, and the quadrotor can achieve centimetre-level positioning accuracy, which meets the requirements of the drone light show.

4. Entertainment drone performance experiment
An entertainment drone, the controller and other auxiliary devices are required to realize the performance experiment of the drone light show. In this paper, the rotating LED display is installed vertically on a quadrotor to form an entertainment drone. In order to achieve the desired performance, we need to realize the control of the drone's position and the rotating LED display. In order to realize the position control of the entertainment drone, this article uses the Mission Planner software running on the computer to edit and generate flight missions, and upload them to the flight controller via wireless data transmission. The flight mission specifies the position, speed and hovering time of the drone, and the drone completes the flight action according to the prescribed route. The RTK positioning system provides high-precision positioning information for the drone. High-precision entertainment drones can more finely control the images presented in different positions and get better performance effects. In order to achieve the control of the picture on the rotating LED display, this
article uses a high-power outdoor AP to achieve WiFi coverage of the performance venue. The rotating LED display and the player are connected to the same WiFi local area network to achieve a stable link. Figure 4 shows the entertainment drone designed in this article. The drone takes off and landed on the landing gear fixed on the ground, this can reduce the weight of the drone and increase the endurance.

Figure 4. The entertainment drone with rotating LED display technology

5. Conclusion
In this paper, the rotating LED display technology is applied to the drone performance, and a quadrotor equipped with a rotating LED display is designed. The drone can display complex patterns, which greatly reduces the cost and technical difficulty of the drone light show. At the same time, multiple drones can form a flight formation, which can display more complex pictures. The drone uses an open-source flight control solution, which is highly expandable. The performance experiment of the drone has achieved a good display effect, which proves the feasibility of this design. However, the current picture played on the drone and the position of the drone are still independently controlled. Further work is needed to realize the synchronous control of the picture and the position, which can achieve better performance effects.

References
[1] Trask, M. (2019) Intel’s Drone Tech Illuminates Night Skies. [online]. https://www.commercialdroneprofessional.com/intels-drone-tech-illuminates-night-skies
[2] Austin, P.L. (2018) A Record-Breaking Drone Show Ended With Quadcopters Falling from the Sky. [online]. https://gizmodo.com/a-record-breaking-drone-show-ended-with-quadcopters-fal-1825745673
[3] Dong, X., Zhou, Y., Ren, Z., & Zhong, Y. (2016). Time-varying formation tracking for second-order multi-agent systems subjected to switching topologies with application to quadrotor formation flying. IEEE Transactions on Industrial Electronics, 64(6), 5014-5024.
[4] Dong, X., Yu, B., Shi, Z., & Zhong, Y. (2014). Time-varying formation control for unmanned aerial vehicles: Theories and applications. IEEE Transactions on Control Systems Technology, 23(1), 340-348.
[5] LIANG, G. S., QIN, J., CHEN, S. H., & CHEN, Z. Y. (2014). Design and implementation of colourful rotating LED display. Chin. J. Liq. Cryst. Disp, 29(5), 850-855.
[6] Ortega, M. X. P., Ramírez, J. C. D., Castro, J. W. V., Carrión, J. L. A., Carvajal, A. A. Á., & Segarra, A. N. G. (2020). Application of the technical-pedagogical resource 3D holographic LED-fan display in the classroom. Smart Learning Environments, 7(1), 1-13.
[7] Bouabdallah, S., & Siegwart, R. (2007, October). Full control of a quadrotor. In 2007 IEEE/RSJ international conference on intelligent robots and systems (pp. 153-158). IEEE.
[8] Eling, C., Klingbeil, L., & Kuhlmann, H. (2014). Development of an RTK-GPS system for precise real-time positioning of lightweight UAVs. In Proc. of.