Tram-based patrol inspection system based on drone

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Abstract

With the acceleration of urbanization in China, many cities in China have been actively planning to invest in the construction of trams, and some trams use ground power systems to power the trams. At present, the inspection of the trams is mostly carried out by means of manual inspection. When the local power supply system fails, the faulty power supply module can only be found by the traditional dichotomy, that is, by temporarily disconnecting the cables in the hand well. ,low efficiency. In view of the low efficiency and high cost of manual inspection of trams , this paper develops a patrol system for trams that combines 5G and wireless charging technology to realize daily inspection and emergency of trams inspection.

Keywords

Tram inspection, wireless charging, 5G technology.

1. Introduction

Modern trams have moderate traffic, reliable operation, energy saving and environmental protection, which is conducive to meeting the increasing urban traffic demand and developing green transportation. However, the traditional manual inspection methods for trams have the disadvantages of high cost and low efficiency, which cannot fully meet their development needs [1,2] .Therefore, how to improve the inspection mode of trams, making them more efficient and lower cost is of great significance for the promotion and application of trams. Because the drone hasexcellent maneuverability and flexibility, and the flying speed is fast, and the attitude of the aircraft is high[3] , this paper proposes a mainframe hardware such as a high-definition camera, an infrared imager, an MCU, and the like. The design and manufacture of charging piles, as well as image recognition, visual navigation, wireless charging, 5G wireless communication and other major technologies, complete the daily inspection and emergency inspection of the track. Daily inspection for every day of the inspection target track after the tram before the start or end of operations, to determine whether a foreign body, large cracks and other defective places on the track, ground power system circuit judge whether there is a short circuit fever The emergency patrol is used to quickly inspect the track and identify the patrol when the ground power supply system is tripped during the running of the flawless tram, and determine which circuit under the track is faulty before the heat source cools down [4] . Or when a traffic accident or other accident near the track prevents the tram from operating normally, the system can be activated to quickly reach the accident point and determine the cause of the accident, to inform the relevant departments to quickly handle the accident. At the same time,the system also plans to lay a self-designed charging pile suitable for the wireless charging of the drone on both sides of the track. When the drone is insufficient in power during the inspection, the GPS navigation and visual navigation can be used to dock with the charging pile. Wireless charging greatly improves the inspection distance and efficiency of the system. In addition, the system has been adapted to rainy days and night inspections.

2. System overall plan

This project is devoted to the development of a patrol system for trams . Combined with the actual situation of the tram, the overall architecture of the system proposed in this plan is shown in Fig. 1. The system is equipped with various testing equipment and communication equipment to form an airborne system through a four-rotor aircraft. During the inspection process, foreign objects, cracks or other defective places above the track of the tram are completed, and the ground power is supplied to the ground below the track. Comprehensive detection of the system.

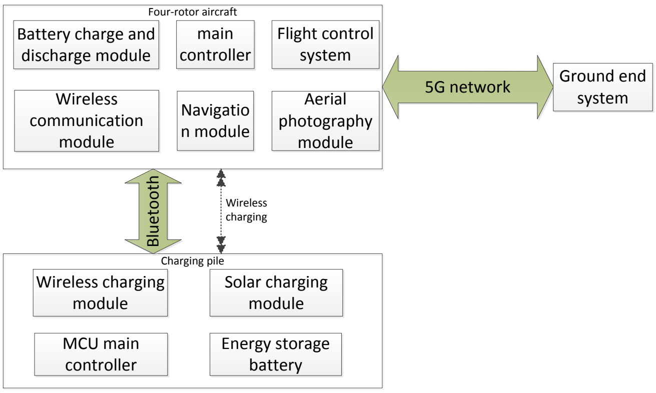

Fig. 1 System structure diagram

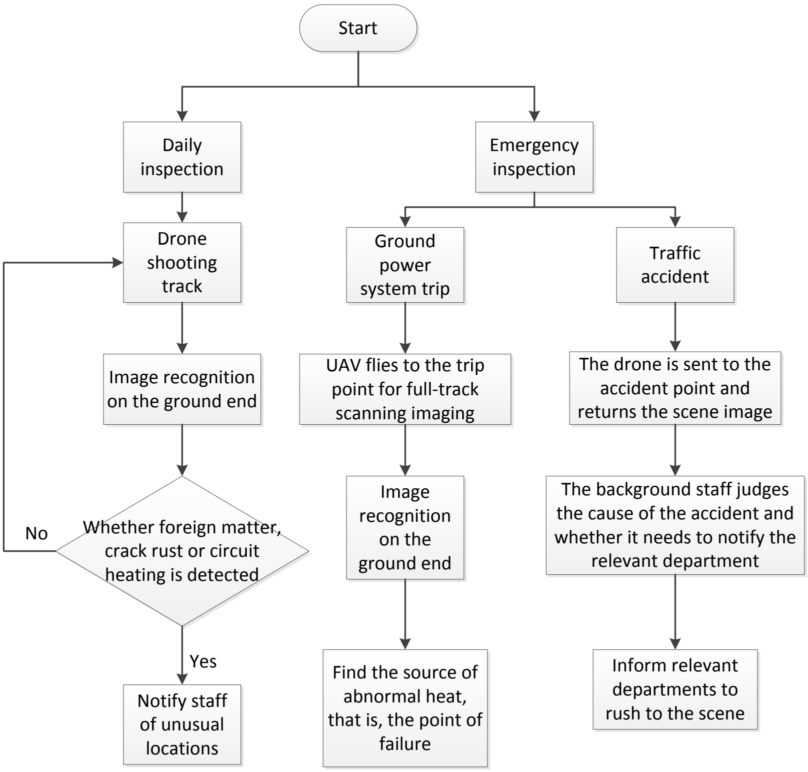

Fig. 2 system work flow chart

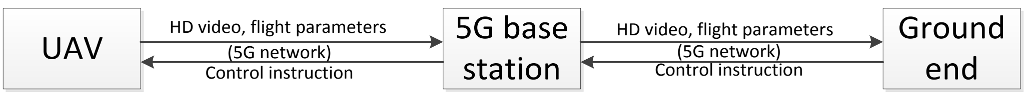

Fig. 3 Schematic diagram of communication between the drone and the ground

The working flow chart of this system is shown in Fig. 2. The four-rotor aircraft designed by this project uses motor-driven aircraft to move. During the aircraft inspection process, the infrared imager, high-definition camera and GPS navigation mounted on the aircraft work simultaneously to complete the high-definition image of the track surface. Acquisition of infrared images of the ground power supply system under the track. After the image acquisition is completed, the image is transmitted to the ground end through the 5G network, and the aircraft communicates with the ground terminal as shown in Fig. 3 below[5-7].

After the image is transmitted to the ground end, the image is processed and recognized by the image recognition software developed by the project, and the image recognition software intercepts the frame of the returned video and then performs specific image recognition. Alarms and flags are issued when an abnormality in the track image is recognized, and then the worker is notified to perform the process.

If there is a shortage of electricity during the patrol of the aircraft, use the GPS navigation and visual navigation technology to fly to the wireless charging pile next to the track and dock it for wireless charging. After the aircraft is fully charged, continue to patrol. task.

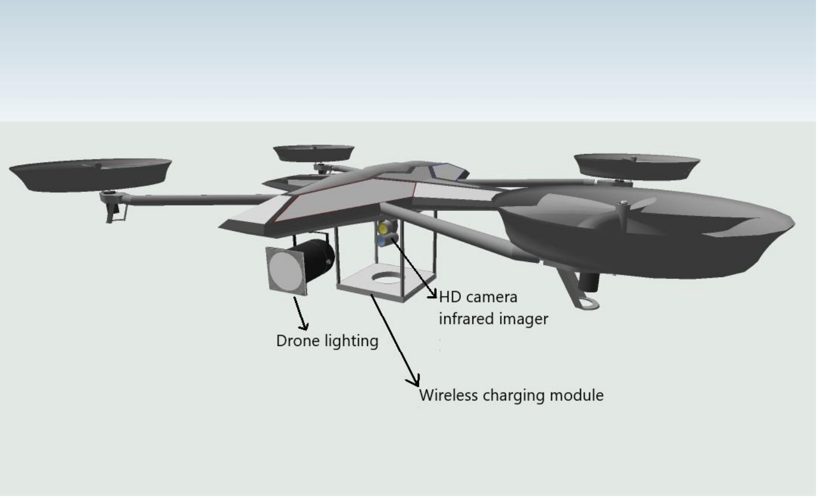

Fig. 4 drone model diagram

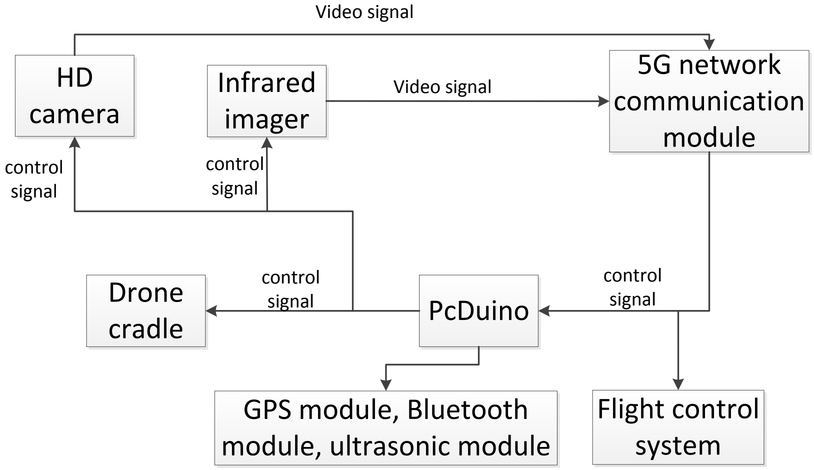

Fig. 5 UAV hardware structure diagram

3. Drone design

The four-rotor aircraft modified by this project is mainly composed of aircraft fuselage, battery charge and discharge module, drone master control, flight control system, navigation module, wireless communication module and aerial photography module. The designed model is shown in Fig. 4 below. The hardware structure is shown in Fig. 5 below.

4. Charging pile design

The program stream is designed UAV charging post as shown below, the main charging post to be composed of five parts, namely, a landing beacon, the wireless charging module, the MCU master, charging solar panels, storage batteries. The model of the charging pile is shown in Fig. 6 below, and the hardware structure is shown in Fig. 7 below.

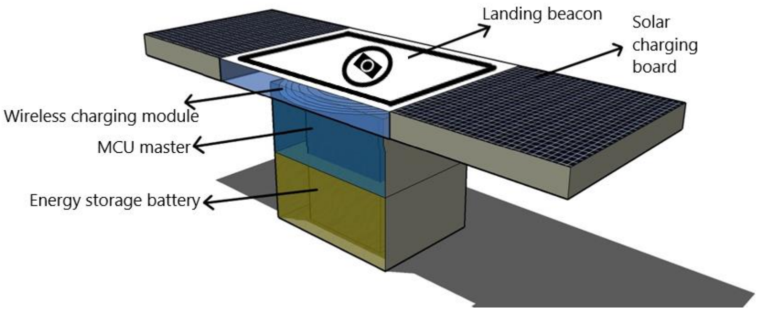

Fig. 6 charging pile model diagram

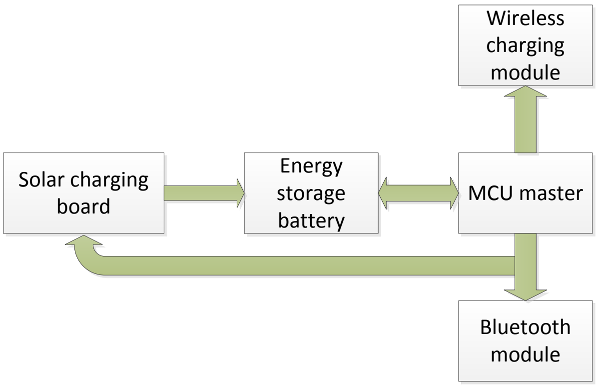

Fig. 7 charging pile hardware structure

Landing beacons are important markers for visual navigation of drones. They need to have features that are easily distinguishable from the surrounding environment and contain sufficient feature information. The landing beacons designed in this scheme are shown in Fig. 8, where the size of the entire landing beacon is At around 45cm × 50cm[8].

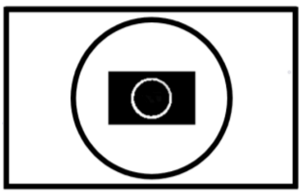

Fig. 8 charging pile hardware structure

5. Ground end system

The ground end system mainly includes: drone ground station software, 5G network communication module, and image recognition software. The PC end connects to the wireless network through the 5G network communication module to communicate wirelessly with the aircraft; the ground station software is the supporting groundstation software of the UAV flight control system , and sends the flight control control command through the 5G network ; the image recognition software adopts python It is written with the opencv development environment to receive high-definition video captured by the aircraft through a 5G network for image recognition and related processing of images.

6. Visual navigation docking design

6.1 UAV visual navigation process

Since substantially only over alone GPS navigation stream for navigation to the charging post, so when the UAV feeder pile over charging, but also with the ultrasonic visual navigation precision docking module and the charging is completed pile. The visual navigation acquires the image information of the ground by using a camera installed directly under the drone, and then transmits the image to the ground end by using a 5G network, and the background computer uses the visual algorithm to recognize the characteristics of the previously set landing beacon, and then uses the setting. UAVs coordinate system determines the relative positions of the landing beacon and adjusting their relative positions, so that the UAV charging post centerscoincide with the center in the vertical direction, and then combine the ultrasonic module is judged that the UAV and the ground The distance of the charging pile is then connected to the ground charging pile, and the flow chart of the visual navigation docking is as shown in Fig. 9 [9,10].

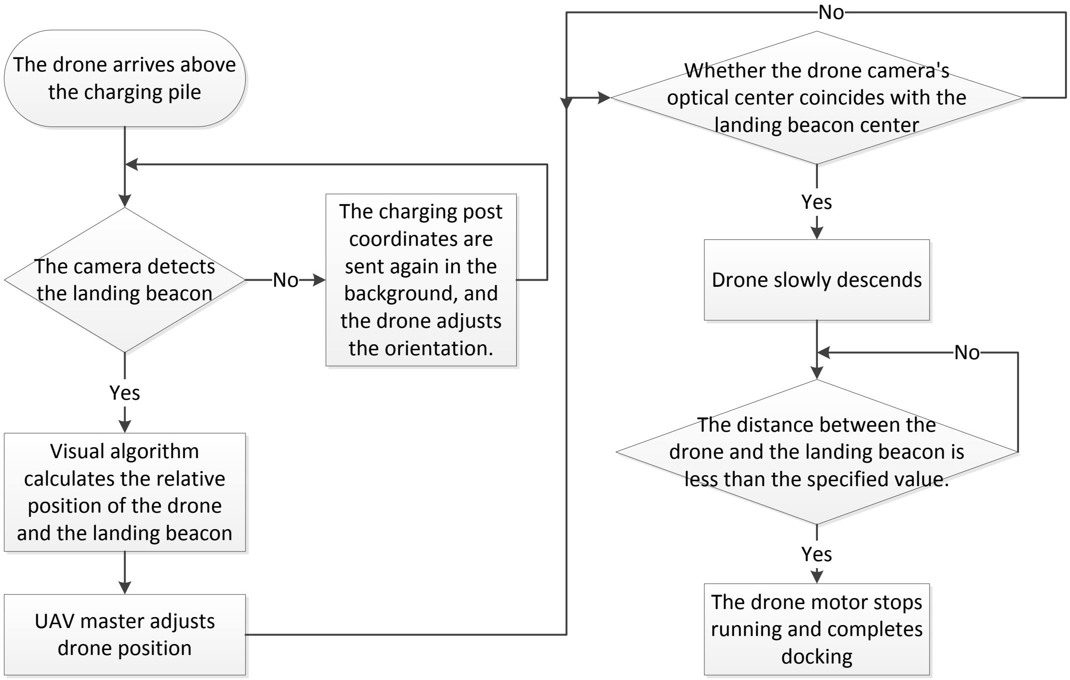

Fig. 9 Visual navigation docking flowchart

7. Wireless charging scheme design and simulation

7.1 Wireless charging scheme design

When the drone is successfully docked with the charging station through GPS navigation and visual navigation, the two parties use the Bluetooth module to communicate, and then start wireless charging after confirming the other party's information. Wireless charging scheme of the present embodiment is used in an electromagnetic induction type, The basic process of wireless charging is shown in Fig. 10 below.

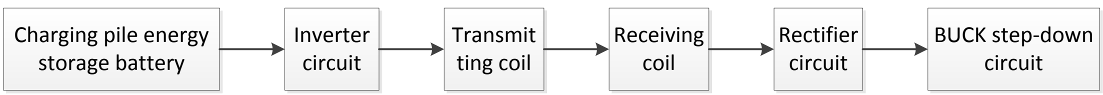

Fig. 10 Wireless charging flowchart

The circuit diagram of the entire wireless charging module is shown in Fig. 11 below[13-16].

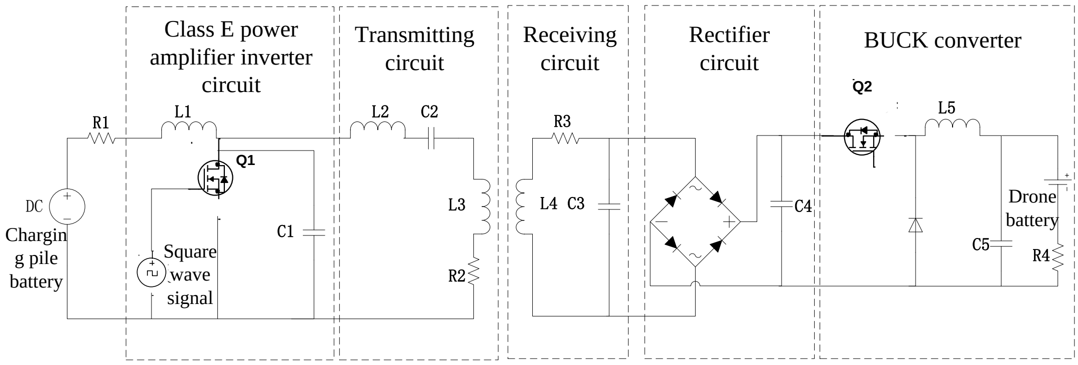

Fig. 11 Wireless charging circuit

The parameters of each component are shown in the table 1 below.

Table 1 Parameters of each component

Components	parameter	Components	parameter
Charging pile battery	36V	R2	0.2Ω
R1	0.1Ω	R3	0.1Ω
L1	3mH	C3	47nF
C1	56nF	C4	56nF
L2	68μH	L5	1mH
C2	1μF	C5	0.47μF

The basic principle of the present embodiment is a wireless charging when the charging post to the UAV chargeacceptance instruction, generating a certain frequency PWM wave, the switching frequency that matches the frequency of the MOS transistor PWM wave. Then, after passing through the E-type power amplifier type inverter circuit, the current is changed from DC power to high-frequency AC power. Then, according to the principle of electromagnetic induction, the receiving coil also generates high-frequency alternating current, and then becomes a direct current through the rectifier circuit, and finally the voltage is passed through the BUCK step-down circuit. Drop the voltage range required by the drone and finally achieve the purpose of wireless charging. After the system detects a fully charged battery, the charging post to stop generating the PWM wave control center, while outputs a low level signal and the MOS transistor off, to stop charging.

8. Image recognition software design

Build python and opencv development environment to process video. The software captures the infrared video stream in real time after initialization . The process of using opencv algorithm is as follows:

The position of the track is first identified. The extraction of the track line is divided into three steps. First, the binarization is performed to obtain the grayscale image of the image, and then the image edge processing is performed to extract the contour of the track line, and finally the inverse perspective transformation is performed to make the transmitted image into a top view. The identification of the track line utilizes the Hough transform to read the line. The infrared recognition area is formed using the most recent two curves that have been identified. The track line identification process is as shown in Fig. 12.

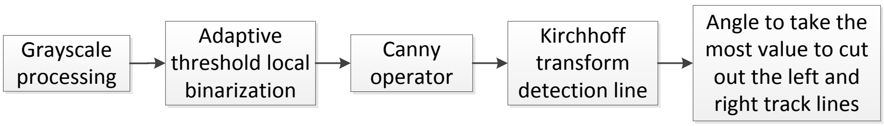

Fig. 12 Track Identification Process

Since the infrared heat map represents different temperatures through different colors, the temperature can be judged by recognizing the color in the image. First, one frame image is obtained from the video source, converted into the HSV color space, and the high temperature color region is searched for. If an abnormality is found, color represents the high temperature region of the masking, which retained the partial region, and then binarizing process into binary image, extracts the outline coordinate array of high-temperature region, marked out with a green rectangle in the respective position of the image After being displayed in the window, the alarm message is sent to the ground warfare, and the next frame image is continuously captured for the same processing. Continuous looping is performed to obtain a continuous video, and the marked abnormal region can be seen from the video, thereby detecting the underside of the track. Abnormal heat from the line or component. The infrared recognition process is as shown in Fig. 13.

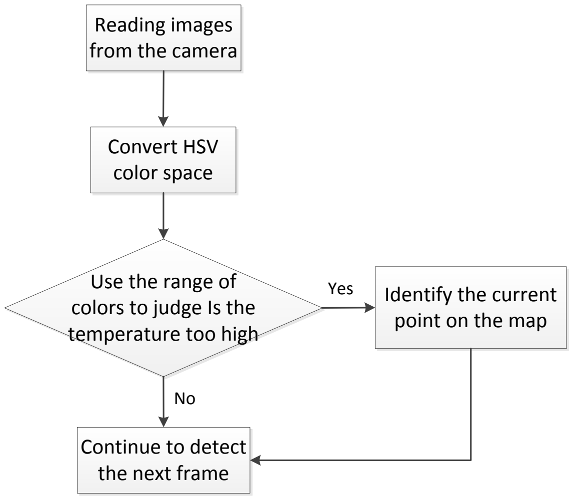

Fig. 13 infrared recognition process

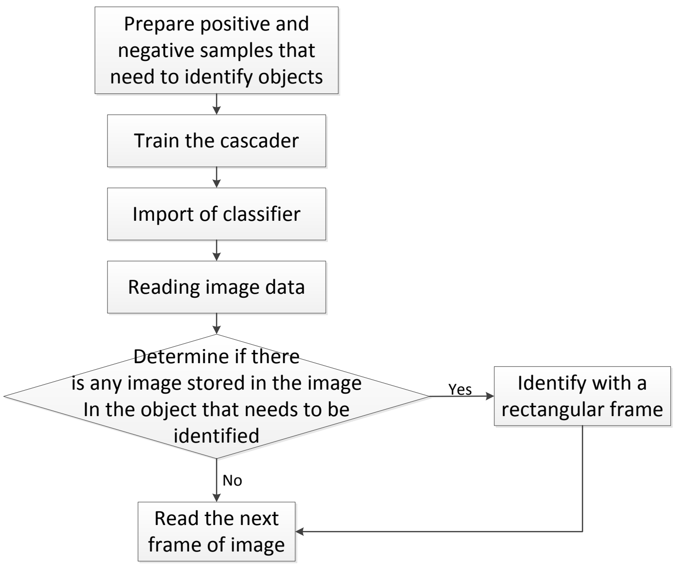

Fig. 14 object recognition process

The specific process of object recognition is as follows: First, you need to set up a database, collect positive and negative examples, set the specification of the required image to 20x20 per block , or use its own function to automatically process (automatically generate sample description file, automatically frame next frame read files within a folder). Generate a description file using the Create Sample Description file, open the Execute Command Training Cascade, and finally generate the required classifier. The specific recognition program is imported into the database, and a frame image is obtained from the video source, and the image is grayscale adjusted to detect whether there is an object to be detected in the image, and the detected object will be identified by a rectangular frame. The object recognition process is as shown in Fig. 14.

9. Conclusion

With the acceleration of urbanization in China and the characteristics of China's large population, many cities in China have been actively planning to invest in the construction of “innocent” trams to solve problems such as traffic congestion and air pollution. After the tram is completed, it is often necessary to inspect it, including the inspection of the track, ground power supply system and road conditions to ensure the safe operation of the tram. This paper proposes a comprehensive inspection of "innocent" trams combined with 5g and wireless charging technology for trams, to overcome the shortcomings of low efficiency and high cost of manual inspection. The system is mainly composed of inspection drones, charging piles and ground end systems. The UAV uses a high-definition camera and an infrared imager to image the track and its surroundings and transmit it to the ground end system for processing and identification to determine whether an abnormality has occurred in the track, the ground power supply system or the surrounding area. The drone judges its own power in real time during the inspection. If it needs to be charged, it uses GPS navigation to fly to the vicinity of the target charging pile, and then uses visual navigation to dock with the charging pile and then wirelessly charge. After the charging is completed, the drone continues. The inspection task has the advantages of high inspection efficiency, long inspection distance and low inspection cost. Through testing, it can be seen that the railroad car drone inspection system combined with 5g and wireless charging technology proposed in this paper can complete the inspection function better. Recently, we plan to conduct on-site inspections on the No. 1 line in Zhuhai, with a view to achieving early application.

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