A design of intelligent delivery drone based on BeiDou navigation and visual processing

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Abstract. This article used automatic control, 5G real-time communication, visual processing and other technologies to design a carbon fiber intelligent delivery drone, based on BeiDou satellite navigation and face recognition. And we proposed a semi-autonomous delivery mode to achieve real-time control of the drone. This mode can reduce flight risks and ensure the safety and accuracy of distribution. The drone can be powered by microcrystalline silicon thin film solar cells. The BeiDou satellite navigation system is used for autonomous positioning, combined with binocular stereo vision technology to observe the surroundings, automatically plan the flight path. On the way, personnel can intervene in real time as needed. Finally, when the drone arrives at the destination, facial recognition technology is used to confirm the identity of the recipient to complete the delivery.

1. Introduction
Under the huge demand for express logistics, traditional manual transportation and distribution face many problems. There are hidden safety hazards when shuttles on roads; traffic jams in densely populated areas or relatively remote destinations lead to long transportation times, high costs, and low efficiency. Therefore, a drone delivery mode with low traffic pressure and low transportation cost came into being. There is a huge market for drones to deliver takeaway, express and other lightweight goods [1]. In addition, the vigorous and rapid development of computer technology, communication technology, battery energy storage technology, material science, etc. provides technical assurance for the research and design of lightweight cargo delivery drones. Nevertheless, it is difficult to produce and use on a large scale due to its large size and high manufacturing and operating costs. Therefore, the design and improvement of intelligent delivery drones are of great significance highly achievable [2].

2. Overall System Design
This design requires the drone to meet the following requirements and functions: high degree of intelligence, safety and stability, capable of precise and efficient autonomous positioning, avoiding obstacles, quickly and safely transporting goods to designated targets, and capable of autonomously completing corresponding functions through cloud communication.

Therefore, this paper designs a delivery drone based on BeiDou navigation and graphical visual analysis, based on the low latency characteristics of 5G. The design includes solar battery power module, image recognition processing module, BeiDou navigation and positioning module, path planning and obstacle avoidance module, cloud communication module and UAV core control processing unit. The system structure function chart is shown as in Figure 1.
Figure 1. The architecture diagram of distribution UAV’S structure and function design.

The drone uses the BeiDou navigation and positioning module to accurately obtain its own position in real time, uses the image recognition processing module to obtain real-time road conditions, and uses the obstacle avoidance module to perform real-time analysis of complex flight conditions and adjust the flight direction and altitude in real time after path planning processing. The semi-autonomous flight mode ensures that human intervention can be carried out at any time during the flight of the UAV to ensure flight safety. When the drone arrives at the designated destination, the drone actively uses the communication module to call the recipient, and when the recipient stands in front of the drone, it uses facial recognition technology to determine the recipient's identity for delivery.

3. Technical realization

3.1. Energy supply

In order to save energy and enhance the drone’s endurance and delivery radius, this design uses a combination of solar panels and battery packs for power supply. This method can minimize costs and improve energy utilization.

In the current commercial market, crystalline silicon solar cells have the highest photoelectric conversion efficiency, but they are difficult to reduce production costs while having high efficiency, and difficult to apply them to delivery drones with a huge application market. So this design uses silicon-based thin film solar energy battery. Thin-film solar cells only need a few micrometers to form a thin film that can generate voltage, and it can also perform high-efficiency photoelectric conversion. It consumes less substrate and has low cost. There are various types of silicon-based thin-film solar cells, but the manufacturing process of efficient polysilicon thin-film solar cells is complicated, when amorphous silicon thin-film solar cells have low conversion efficiency and have light-induced degradation effects. Combined with the market's research on silicon-based thin-film solar cells, this design selects microcrystalline silicon thin-film solar cells [3]. The preparation process is similar to that of amorphous silicon thin-film solar cells, and there is basically no light-induced degradation effect. And the manufacturing cost is low, which is conducive to the large-scale application of the distribution drone.

However, for the delivery drones that need to fly long distances and have a large load capacity, only relying on solar panels for power supply is not stable enough, but also requires the support of battery packs. This design uses a lithium-ion battery pack. Lithium-ion batteries have high energy density, long life, good economy and safety, and their technological development is relatively mature. And they are widely used in various fields. Therefore, the lithium-ion battery pack is very reliable as a strong backup energy for drones.
3.2. Satellite positioning and visual obstacle avoidance

The scope of cargo distribution is wide, and there are many roadblocks when the distribution drones fly. How to ensure that the drones can accurately avoid obstacles and transport cargo safely is the main task of the obstacle avoidance module. At present, the detection of obstacles is mainly researched from the aspects of laser, infrared, ultrasonic, radar, GPS and machine vision. Among them, the ultrasonic obstacle avoidance detection distance is relatively short, and the three-dimensional contour recognition accuracy is not high, but it can recognize transparent materials such as glass. Laser obstacle avoidance detection has high accuracy, strong anti-interference ability, wide effective range, but expensive, which is a negative factor affecting large-scale commercial production. Computer vision obstacle avoidance, such as the obstacle avoidance method based on the depth camera, is not stable enough, is easily affected by environmental factors, and occupies a large volume and weight, which is not conducive to the high-speed flight of drones. Based on the above factors, this design adopts a domestic high-precision satellite navigation system-BeiDou satellite navigation system, supplemented by a comprehensive navigation mechanism of computer vision obstacle avoidance processing, and uses the collected geographic terrain data for analysis to achieve obstacle detection accuracy Higher [4], improve the efficiency of obstacle avoidance.

In the design, the BeiDou positioning module completes the functions of positioning, navigation, and timing. The data processing uses the STM32F103 microcontroller, which has low power consumption, rich on-chip resources, strong processing capabilities, and low cost and stable performance to meet the design and application requirements. The BeiDou navigation module measures its position in real time, and at the same time uses binocular stereo vision navigation technology to measure the distance of obstacles based on the principle of triangulation distance measurement, and then uses the midpoint to establish a virtual space coordinate system. Then the position data of the obstacle in the coordinate system is used for path planning through the path planning algorithm to realize the function of obstacle avoidance navigation. The binocular stereo vision technology uses two cameras to dynamically capture original images. There is path information after the images go through the preprocessing process, coordinate system establishment, static target extraction and other processes. The image preprocessing process of the path planning algorithm is shown in Figure 2.

![Image preprocessing flowchart](image)

**Figure 2.** Image preprocessing flowchart.

3.3. Semi-autonomous flight and ground monitoring

As a UAV with its main function of logistics transportation, it needs to fly in a complex environment. Therefore, in order to reduce the technical difficulty of manufacturing, reduce costs, and improve the feasibility of wide application, this design proposes a semi-autonomous UAV delivery system. In the delivery process, the drone uses 5G communication and satellite positioning obstacle avoidance system to carry out autonomous flight on the main wide road section, and the drone controller performs remote control on the complex road section based on the road condition data returned by the drone in real time.
This kind of distribution system can improve the safety factor and delivery efficiency in the delivery of drones, and reduce the accident rate caused by the mistakes of autonomous selection of drones in complex road conditions. It is worth noting that the key to the semi-autonomous UAV distribution system is the low-latency communication and the division of flight sections. The low-latency communication is guaranteed by the stable and high-speed 5G network, and the flight section is artificially divided according to the real-time location of the drone through the ground console, ensuring that the operator can intervene at any time and improve the delivery success rate.

3.4. Authentication by face recognition

The face recognition module completes the function of collecting the facial features of the recipient and comparing the identity of the recipient with the destination of the goods through the network. The module uses the STM32F407 single-chip microcomputer with low power consumption and stable performance as the processing core, and uses the Open MV camera equipped with a powerful 32-bit processor to collect the recipient's face image. The external display screen displays the collected avatar so that the person can adjust in real time. Posture completes identity confirmation. The module uses the STM32F407 single-chip microcomputer with low power consumption and stable performance as the processing core, and collects the recipient's face image through the Open MV camera equipped with a powerful 32-bit processor, and the external display shows the collected avatar, through which the collected person can adjust the correct posture in real time to complete the identity confirmation.

In the selection of face recognition algorithms, this design uses the optimal orthogonal transformation technology in image compression—PCA technology based on K-L transformation, which can well highlight the differences while reducing calculations, increasing the recognition rate and reducing the burden on the processor. Principal component analysis technology uses a special vector matrix U to project a high-dimensional vector into a low-dimensional vector space, which is represented as a low-dimensional vector, to achieve the function of compressing information. In the process of transforming the original high-dimensional vector to a low-dimensional vector, the information contained in the original vector only loses part of the secondary information, which will hardly affect the recognition accuracy when applied to face recognition. The main process of the algorithm application is shown in Figure 3.

![Figure 3. The main flow chart of PCA algorithm application.](image)

3.5. Wing design and fuselage material selection

In order to adapt the solar panels to the high-altitude environment and enable them to work normally and efficiently on the UAV fuselage, this design attaches the solar panels to the wing, which adopts a
"flat" airfoil. The "flat" airfoil has the potential of high lift and low drag, which helps to reduce the energy consumption of UAV flight while increasing the flexibility of the fuselage during flight.

For the material selection of the drone body, due to the high load and long endurance requirements of the drone, the design needs to choose a lightweight body material with low density and strong hardness. This design uses carbon fiber as the main material of the drone body, which has good flexibility, excellent mechanical properties, and the cost performance is better than other such as titanium alloy and traditional aviation aluminum alloy.

4. Conclusion
This article introduces a UAV design idea based on 5G communication and BeiDou satellite navigation system that can realize semi-autonomous delivery of express delivery. The design is based on the low-latency 5G communication network for data transmission, and the high-precision BeiDou navigation system is supplemented by binocular stereo vision navigation technology to perform real-time positioning and path planning to achieve the function of obstacle avoidance navigation. The design uses silicon-based thin-film solar cells and lithium batteries to provide power for semi-autonomous flight. It improves the control of drones and the safety and efficiency of delivery by combining the two methods of autonomous drone flight and ground control flight. In the stage of goods receipt, the face recognition technology is adopted, and the OPEN MV camera and single-chip microcomputer are used to identify the identity of the recipient based on PCA technology. In general, this design adopts the current advanced automatic control technology and computer processing technology, combined with the basic discussion of some structural components of the UAV, and proposes a design of simple structure, low cost, strong applicability, environmentally friendly express delivery drones [6], which can provide solutions for the rapid and efficient delivery of express delivery and other lightweight goods.

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