PSYCHOLOGY AND EDUCATION (2021) 58(5): 7893-7898
ISSN: 1553-6939

A rotary-wing disaster collection drone designed for coastal areas

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ABSTRACT

Natural disasters are particularly frequent in the world, with man-made disasters occurring from time to time. Natural disasters turn into catastrophes when people's lives and livelihoods are disrupted. Currently, technologies such as artificial intelligence drones, which are widely researched in countries around the world, are being used. As emerging technologies, they are drawing more attention. In this paper, we propose a more targeted, rotor-wing UAV design concept applied to disaster information collection for disasters that are prone to occur in coastal areas, and offer new ideas for conducting UAV research.

Keywords
Drones， Information Collection， Coastal Cities

1 Introduction

The frequent occurrence of major natural disasters worldwide is characterized by high suddenness, wide range and destructive power, which often causes serious damage to the communication and transportation systems in the disaster area, and prevents rescuers from getting to the disaster area in the first place to understand the situation and deploy relief work blindly and without target. UAVs are becoming more and more frequently involved in disaster situation collection and are gradually becoming one of the most important and indispensable means of obtaining disaster information. The use of drones can quickly enter the center of the disaster area to carry out disaster collection work, timely access to accurate information for rescue and relief, and can effectively avoid casualties among disaster relief personnel. Most of the drones involved in disaster collection work today are ordinary aerial photography type drones, which have no problem performing collection tasks under normal weather conditions, but when dealing with special weather conditions, they often suffer from many restrictions and can not work properly to provide accurate and effective disaster information to rescue workers. About 80 percent of the world's major cities are located in coastal areas, (see Fig.1.)which aremost vulnerable to natural disasters and are home to 44% of the world's population[i], according to materials from the International Conference on "Global and National Strategies for Disaster and Natural Disaster Risk Control. In its latest data booklet, World Cities 2018, the United Nations Department of Economic and Social Affairs warns that nearly three-fifths of the world's cities have at least 500,000 residents at high risk of natural disasters[ii]. This necessitates the use of a professional drone for disaster collection in coastal areas. I practiced styling and design for coastal area disaster collection drones to provide input for drone development.

Figure 1. Coastal City **-** Busan.

2 The overall structure of the disaster collection UAV

The conventional types of drones are single-rotor (helicopter-style), dual-rotor (left, right, or front and rear distribution of rotors), quad-rotor, six-rotor, eight-rotor, and so on; there are also many unconventional models, such as three rotors into a Y arrangement of drones, which provides greater flexibility. Feature comparison analysis is shown in Table 1.

2.1. UAV model analysis

The application of drones for information collection work is more common. Foreign applications in the field of information collects necessitates the use of a professional drone for disaster collection in coastal areas. I practiced styling and design for coastal area disaster collection drones to provide input for drone development. Town of UAV modeling, design is mostly used for military, civilian only Inter and a few other companies in the design and development. (See Table2.)

Table1. Rotor classification

Classification	Pictures	Advantage	Disadvantages
Single Rotor		Simple structure	Poor maneuverab-ility
2-rotorr		High endurance	Easy to crash
3-rotor		High mobility Low cost Energy saving environmental protection	Not easy to set up flight control system
Rotor Multi-rotor		High load capacity Simple flight control Safe and reliable	Bulky and heavy Energy consuming

Table 2. UAV modeling design analysis

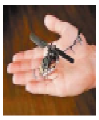
Model	Field	Application	Styling features	Comparative Analysis	Pictures
PD-100 "Black Bee" micro UAV (UK)	Milit-ary	In 2013 in Afghanistan, the British Army used the Blackjack to conduct enemy reconnaissance.	Bionic styling design, the aircraft is about 10 cm long and weighs only about 16 grams. It can carry multiple camera devices and can fly at a maximum speed of 11 mph.	The airframe is small and used for military acquisition and is not easily detected locally. Can only perform missions at close range and short duration.	
Inter Falcon 8+ (USA)	Civili-an use	It can perform aerial mapping and surveying tasks.	The system is mainly composed of three parts: the eight-rotor flying machine, remote control and intelligent battery. Its fuselage adopts a bee-like yellow and black color scheme. The special V-shaped 8-rotor structure, the gimbal is set on top of the nose, the whole shape is full of bionic sense. It can load 0.8 kg objects.	The shape has bionic design features and faster flight speed. However, the shape is not aerodynamic and is not conducive to information collection in windy conditions.	
DJI-Phantom (China)	Civil use	Aerial photography, survey	All-in-one quad-rotor design, equipped with a number of core technologies, long life, stable flight, simple operation.	Beautiful shape and streamlined profile. However, the collection device has no protection device, which is easy to cause losses and affect the collection timeliness.	

Table 3. Analysis of common disasters in coastal areas

Type	Name	Characteristics
Ocean Disasters	*Storm Surge Disaster*	A storm surge disaster is a disaster caused by typhoons, temperate cyclones, strong winds from cold fronts and sudden changes in pressure and other strong weather systems that cause abnormal lifting and lowering of the sea surface, causing loss of life and property
	Sea wave disaster	Usually referred to as catastrophic waves are waves of more than 6 meters high at sea. They can often overturn ships and destroy marine and coastal projects.
	Sea ice hazards	Sea ice refers to salt water ice made directly from the freezing of sea water, and huge ice blocks and icebergs floating on the ocean can have a catastrophic effect on oil platforms and ships at sea.
	Sea Fog	Disasters caused by fog in coastal or marine areas. Sea fog mainly affects marine navigation and even causes maritime disasters such as ship groundings and collisions.
	Hurricane disaster	A tropical cyclone with a force of 12 or more is called a hurricane, but it also refers to gale force winds and any tropical cyclone and any gale with force 12 winds. Extremely destructive
	Earthquake and Tsunami	A tsunami is a powerful, destructive and catastrophic seawave.
	Seawater intrusion	Seawater reaches the land through the surface of the hydrological phenomenon of typhoon season or heavy rainfall is also easy to trigger seawater backflow. This can lead to problems such as soil erosion and salinization of fresh water in coastal areas.
	Oil Spill Disaster	Oil industry and shipbreaking industry, wastewater discharge, etc.. It destroys the marine ecological balance and seriously harms marine life.
Marine Accidents		Ships, submarines, and other vessels in the course of maritime transportation that are involved in major accidents caused by natural or man-made causes, resulting in the deaths of those on board or the loss of goods and property emergencies
Fire disasters		refers to disasters caused by uncontrolled burning in time or space.

3 Coastal disaster collection UAV design process

3.1 Analysis of common disasters in coastal areas

We make the development of UAVs more targeted by collecting the characteristics of common marine disasters. (See Table3.)

3.2 UAV information collection process

This paper takes the example of a maritime disaster in a coastal area. In the ground control system group control system (GCS), the detection area is divided for each UAV (3), and the detection path using the optimal path search algorithm is transmitted. 2. Each UAV flies on the designated path to monitor the disaster. 3. Transmitting information to GCS in case of detecting a disaster at sea. 4. Deploying UAVs with beam projectors to the dispatched area while rescue services are dispatched. 5. Provide rescuers with visual information on maps containing information on the location of the disaster. （See Fig2.）

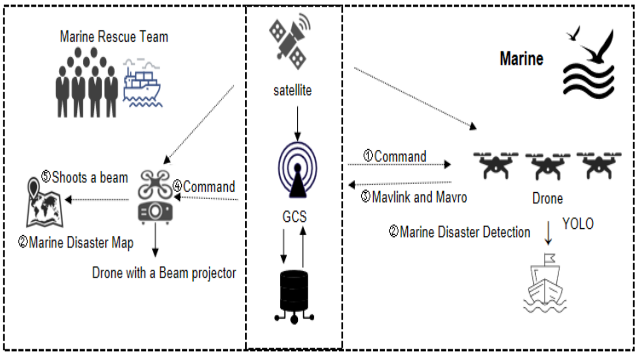


Figure 2. UAV information collection process

3.3 Overall structure of the disaster drone

The optimal flight path is derived in GCS using an optimal path search algorithm. The derived flight path is transmitted to Pixhawk2 The Cube Black via telephone radio. While the UAV is flying in the specified path, the Jetson Nano uses the Micro Air Vehicle Link (MAVLINK) based ROS package MAVROS to transmit the RaspbrryPi camera captured images to the GCS. In the Jetson Nano, the Raspberrypi camera and You Only Look Once (YOLO) are used to determine if there is a maritime disaster. If a disaster at sea is deemed, the Jetson Nano receives the current coordinates from the Pixhawk2 The Cube Black and transmits them to the GCS along with the disaster photos. (See Fig3.)

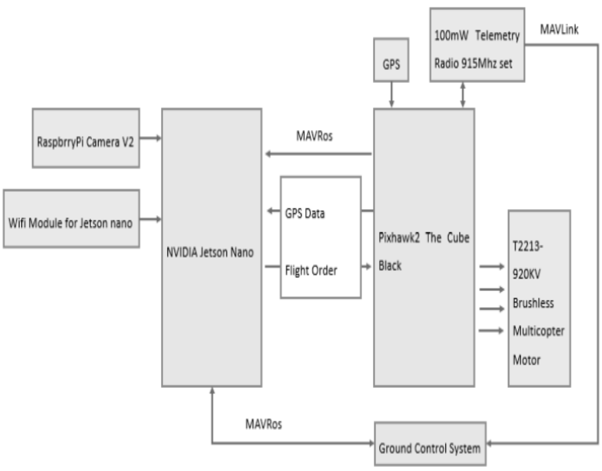


Figure 3. Architecture Diagram.

3.4 UAV image information collection

The most important part of the disaster information collection is the image video information collection. In the camera system, the process of acquiring images conforms to the principle of central projection framing. In the figure, S denotes the center of photography, and f denotes the focal length of the lens. A and B is physical points on the ground, and let the coordinates of the ground coordinate system of A and S be (XA, YA, ZA) (XS,YS, Zs) respectively. a and b is the imaging points of A and B in the plane, and let the coordinates of the image plane coordinate system of a bee (x, y), so the central projection conformation equation can be expressed as follows. (See Fig4.)

$$\begin{cases} x = -f\dfrac{a_1(X_A - X_S) + b_1(Y_A - Y_S) + c_1(Z_A - Z_S)}{a_3(X_A - X_S) + b_3(Y_A - Y_S) + c_3(Z_A - Z_S)} \\ y = -f\dfrac{a_2(X_A - X_S) + b_2(Y_A - Y_S) + c_2(Z_A - Z_S)}{a_3(X_A - X_S) + b_3(Y_A - Y_S) + c_3(Z_A - Z_S)} \end{cases}$$

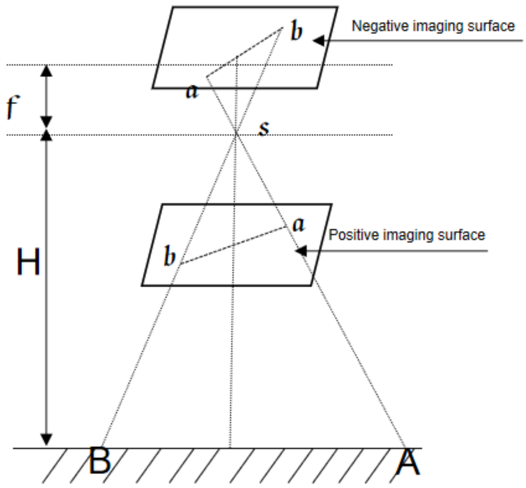


Figure4. Principle of image presentation

Because of various factors, aerial images produce various geometric distortions. Whether the aberrations are generated by the camera system or randomly, they make the geometry of the image deviate from the actual geometry of the object projected onto the map, and the image correction is performed by applying the nearest neighbor interpolation method.

4 Demand analysis of UAV modeling design

4.1Analysis of the demand for styling design in the harsh conditions of the disaster area

When the UAV is used to collect disaster information in the face of special climate and terrain in disaster areas, in terms of styling design, it is firstly required to meet the basic requirements of various flight modes such as vertical take-off and landing, intelligent obstacle avoidance, and fixed-point hovering. Secondly, based on the special use of the subject, special climatic factors of the disaster area should be taken into account to ensure the task of collecting disaster information under bad weather conditions. And for the disaster area, the terrain is more complex and changeable, and also requires the UAV landing gear device to adapt to the special terrain of smooth landing and support.

4.2 Analysis of styling design requirements for acquisition equipment.

First, the styling design should play a protective role in the acquisition of equipment. Second, a multi-axis gimbal needs to be used to carry a high-definition image acquisition device in order to perform a variety of integrated tasks such as image acquisition, search, and reconnaissance. At the same time, the UAV needs to be equipped with a modular device for the image transmission technology, which can transmit captured images to video terminals (display devices, cell phones, VR glasses) in real time. In the modeling, design, it is necessary to consider the placement of transmission equipment, which has achieved better synchronization signal effect.

4.3 Analysis of the demand for power supply system for UAV modeling design

In order to avoid the short flight time of the UAV, it often needs to return to replenish energy, and cannot perform the task in the long term situation. Requirements applied to the disaster collection A UAV power supply system should not rely on a single source of energy, but rather on at least two sources of power, one of which should be renewable, such as solar energy. This can make the UAV more efficient to complete the task of disaster collection. On the other hand, it can also be green and save the consumption of non-renewable energy.

5. Design practice

5.1 Design ideas

Considering the special climatic factors in the disaster area, the design is based on bionic design and aerodynamics with reference to the characteristics of birds with spindle-shaped bodies and streamlined profile. The upper surface of the fuselage design is a smooth surface, while the lower surface is a plane. The airflow speed on the upper surface of the fuselage is greater than the airflow speed on the lower surface, so the pressure generated by the airflow below the fuselage is greater than the pressure of the airflow above. In order to meet the needs of the UAV to be able to take off and land vertically and hover at a fixed point, the shape design is based on a three-rotor UAV."Weight", the engineering material on the rotor, is made of carbon fiber, which is lightweight and tough at the same time. The light system modeling, design also belongs to an important part of its fuselage modeling, design, and needs to be designed in strict accordance with international air vehicle standards. The red anti-collision light and high-brightness white strobe light was designed to alert the aircraft; the wing light, located in the front middle of the wing, can illuminate the Falcon in low visibility; the navigation mark light, located on the left side of the fuselage, can brighten the logo for aesthetic effect.The built-in landing gear is installed at the front of the landing gear to illuminate the ground during takeoff and landing. The landing lights are installed at the front of the landing gear to illuminate the ground during takeoff and landing. Five sets of binocular environmental vision sensors design on the front, rear, top, bottom and both sides of the fuselage to enable it to sense obstacles in all directions. Micro SD memory card mode is used so that in case of accidental damage to the drone, the collected graphic data information can be saved in the memory card and subsequent rescuers can find the drone and use the collected data for the application. In order to help the internal components to dissipate heat, its overall shape plan uses aluminum alloy uni body molding technology to achieve a seamless joint between the components, the surface and lines overlap and interlock, giving off a unique sporty atmosphere. The UV coating is applied to the surface for corrosion protection and to make the drone look and feel better.（See Fig5.）

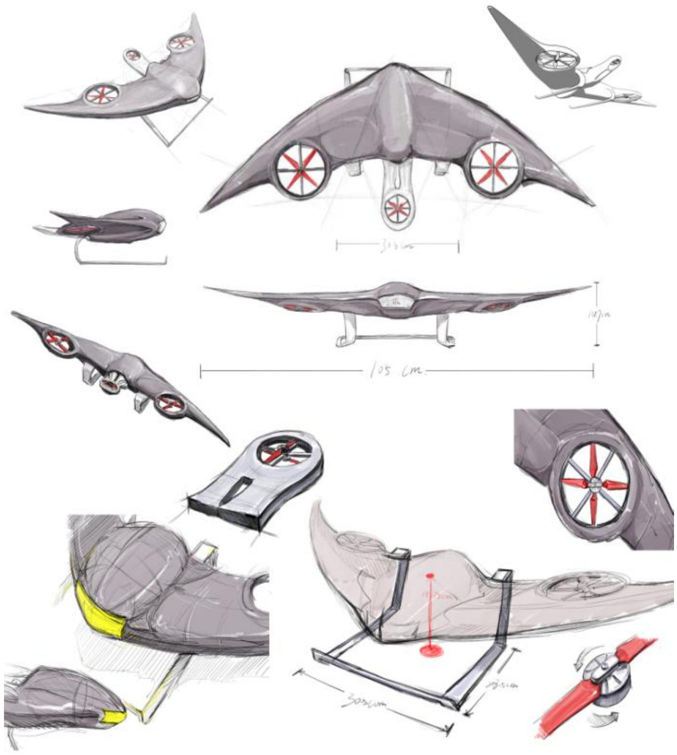


Figure 5.Sketch.

5.2 Renderings and CAD drawings

We used MAYA software to model the previous sketches in three dimensions.（See Fig6.） And the 1:1 dimensional six views of the drone were accurately calculated with CAD.（See Fig7.）Final Product Present and Specifications.（See Fig8.）

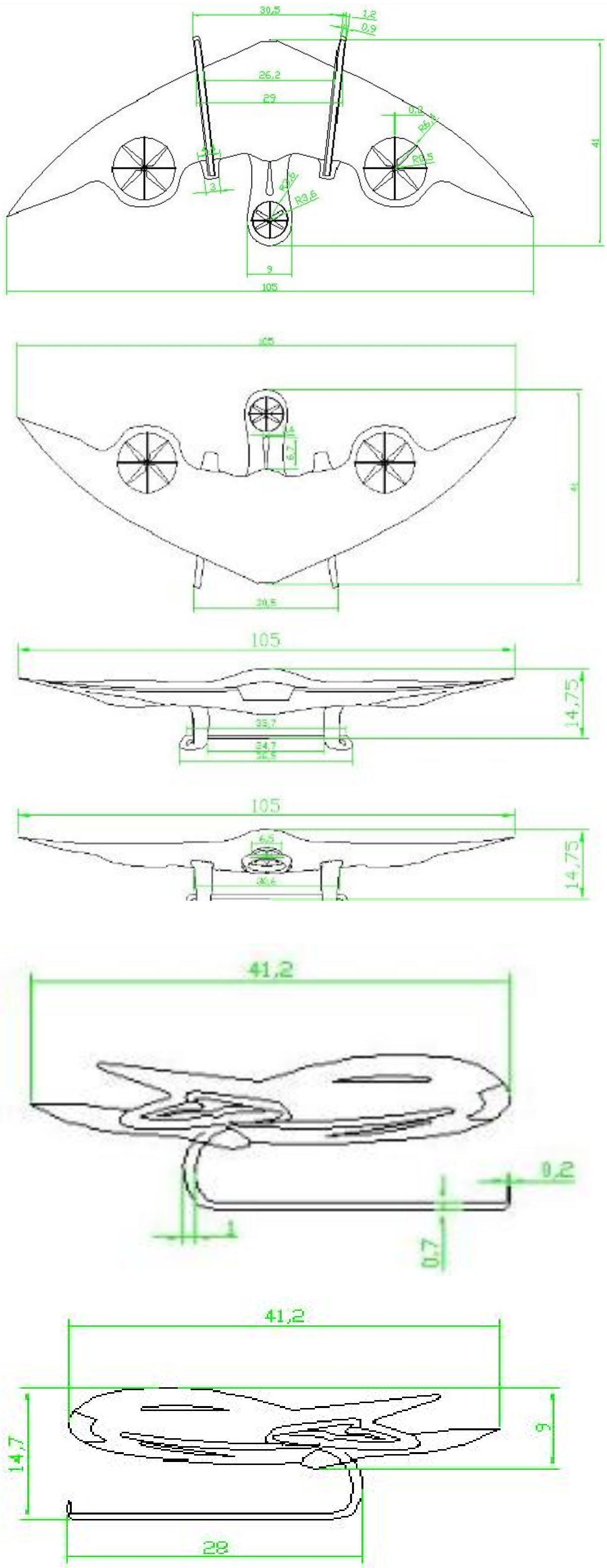


Figure 7 . Six views of CAD dimensions

Figure 8 . Final product show

6.Conclusion

This study only research and designs in the shape form of the rotary-wing UAV applied to disaster collection. The scope of the research can be further expanded in the future, and the concept of researching disaster collection systems can be continued to be introduced based on the research of this paper, so that it can form a more perfect integrated rescue collection system to better serve human beings.

Acknowledgement

*This work was supported by a grant from Brain Korea 21 Program for Leading Universities and Students (BK21 FOUR) MADEC Marine Designeering Education Research Group.

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