The technical description

IARC Mission 7 is a highly complicated task for aerial robots, requiring them to be intelligent and robust enough, which demand much effort on both the hardware and the software. After careful analysis of the mission, we determined that the research should be focused on flight control and visual navigation.

What we have done:

- Set up the flight platform.
- Set up the communication structure.
- Design visual navigation programs.
- Design programs for processing visual data.

Part one: Research Devices

We would use DJI Matrice 100 (M100) quadcopter as our flight platform. On the platform, there would be a core flight controller, a set of Guidance visual sensing system, an INTEL NUC5i5RYH mini computer, wireless data transmission modules and other accessories.

M100, produced and monitored by DJI corporation, provides application programming interface (API) and software development kit (SDK), which means that users are allowed to develop their own flight applications by programming in a highly flexible way.

Part two: Research Target

According to the requirements of the mission, we made a two-step scheme. The first step is to reach the basic goal, which is designing programs to enable the quad to hover, track targets and avoid obstacles. The second step is based on the first. It would include further development of controlling methods to give the quad more advanced abilities.

1.1 Elementary object

- Achieve control program by a key which designed to make the aircraft autonomous takeoff, independent hover, autonomous landing after takeoff.
- Design a visual process on-board camera to collect pictures, and it is able to identify the target cars and border line.
- Design a communication obstacles application which can read the Guidance data, and combine with other navigation information sent to the ground station for processing.
- Design a ground control program which based on the collected navigation information, and it can send instruction to the flight controllers, making the aircraft autonomous avoid obstacles and keep on a cruising altitude in flight and track car movement.

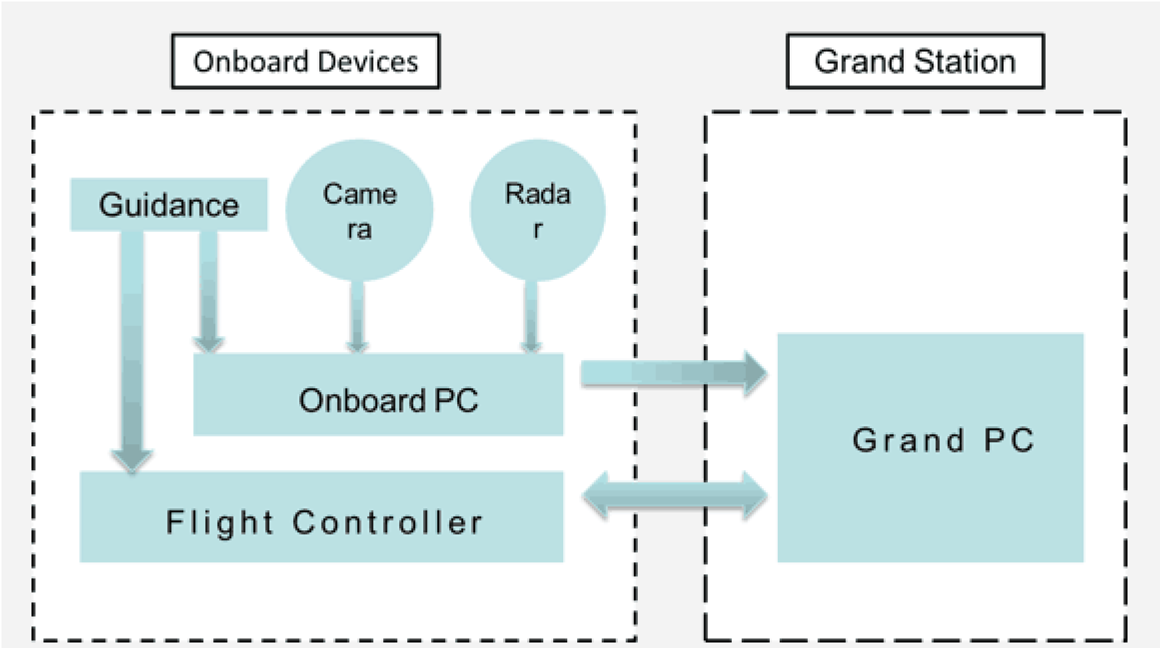
1.2 Advanced target

- Combine with the global map, the technology of image splicing return vehicle position information in real-time.
- Adjust the flying height and the proportion of image pixel distance, making the image processing program to adapt to different altitude.
- On the basis of stable tracking ground targets for autonomous landing of flight vehicle to drive the car, and independently take off again.
- Establish mathematical model and algorithm, and designed to make the vehicle orientation driven all target vehicles, meeting the mission requirements.

Part three: Research Contents

3.1 Systematic review

The navigation control system (following referred to as "system") that our team adopted contains the airborne terminal and the ground two parts. As shown in figure 1, figure arrows indicate the direction of data transmission.



(Figure 1: System overview)

The airborne end information collection devices are the Guidance and airborne camera. The information processing devices is onboard computers and flight controller (fowling referred to as the flight control). The Guidance have a total of five acquisition module and a processing module, and the five acquisition used for gathering aircraft flight height, flight velocity and the distance from ground obstacles.

The data collected by guidance will be sent to both the flight control and the on-board computer. The on-board computer will operate the visual program to calculate the location of the ground robot and the border. After calculating, the on-board computer will sent all the information to the station.

After ground station receiving the location information, it will get the targets based on the priority judgment and the control strategy, and it will generate the flight instruction. The instruction will sent to the flight and realize the flight control.

The ground station will also transfer the SDK, to receive and record the flight status, flight control sends down for flight monitoring and program debugging. The flight combine with the guidance will sent the comprehensive information to the ground station.

3.2 Program design

Control program operation on your computer on the ground station, the ground station receiving the data calculates by the visual system to the flight control to achieve the obstacle avoidance, maintain limits, tracking for the aircraft to do car and hover. The date sent by the visual program is the relative position.

After decoding, control program do priority judgment. Priority from high to low are obstacles, border, target, the car, the recognition to the high priority target, the low priority of target will automatically ignore.

According to the highest priority in the position of the target, the control program generate aircraft flying target. The target is a three element coordinates, the origin of the coordinate system for airborne camera view center, X, Y, Z axis pointing in line with the body coordinate system. Among them, the coordinates X, Y get from solving the obstacle, border, or the level of the car position. Z coordinates for vertical coordinate. Fixed high hover state, the coordinate values are 0. When the actual height and the craft are a far cry from a preset hovering height, the coordinate values will be adjusted accordingly. In the experiment, when the flight control sent aircraft true height at 1 he frequency, the ground station refresh a highly directive every two seconds, we can obtain good fixed high effect. When the aircraft hover, aiming at the current location point, the coordinates is (0, 0, 0).

According to the flight target in each coordinate axis numerical, generate X, Y, Z direction of the speed instruction. If the speed of the aircraft is fast, the pictures collected by the airborne camera will ambiguity. So we need to soften the speed command to achieve the best result.

We can also directly send the speed command to the flight control by SDK package. The send frequency will be set to 50Hz during experiment. When the flight-control receives and decodes the date, the speed command to refresh one time, otherwise remain in last state. If continuous decode error or not receive date long time, the flight will hold hover.

3.3 Data transmission

The dates received by the ground station include the direction of obstacles, the obstacle distance, and border position, the position of target robot. Data receive by the serial port. Communication protocol is shown in figure 2.

Data Field	Size(Byte)	Data Type	Description
Head check	1	char	'A'
Height	4	int	The Height Of the Aircraft to the Ground
Direction Of Obstracle	1	char	Front Right Back Left Void 'a' 'b' 'c' 'd' '0'
Distance Of Obstacle	4	int	
Right & Left Border	1	char	Back:'a' Front:'b' Void:'c'
Front & Back Border	1	char	Left:'a' Right:'b' Void:'c'
Car Direction	4	int	The Height Of the Aircraft to the Ground
X-coordiante of Cars	4	int	Basing on the Body Coordinate System
Y-coordiante of Cars	4	int	
Position-X	4	int	Basing on the take-off Positon
Position-Y	4	int	
Position-Z	4	int	
Rear Check	1	char	'B'
Totle Length	37	NB:Distance are in millimeters; 0 is returned if there is none.	

(Figure 2: Communication Protocol)

According to the protocol, the decoding date includes obstacles, border, and the location of the target robot. The robot coordinate value in the body is the center coordinates of the actual value. Boundary coordinates are discrete values, include (0,0), (0,±1), (±1,0), (±1, ±1), nine values, what they represent shown in figure 3.

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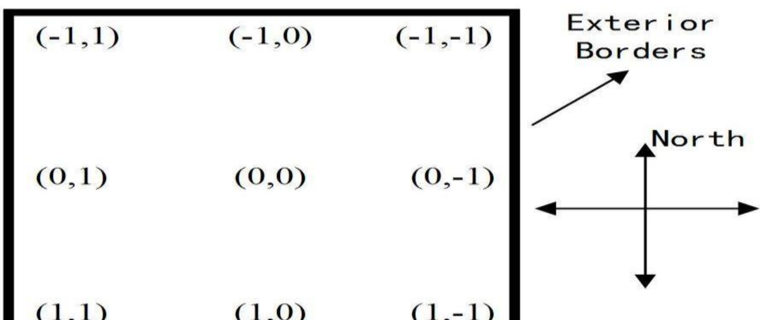
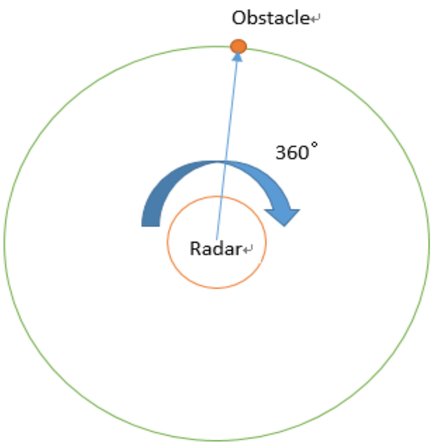
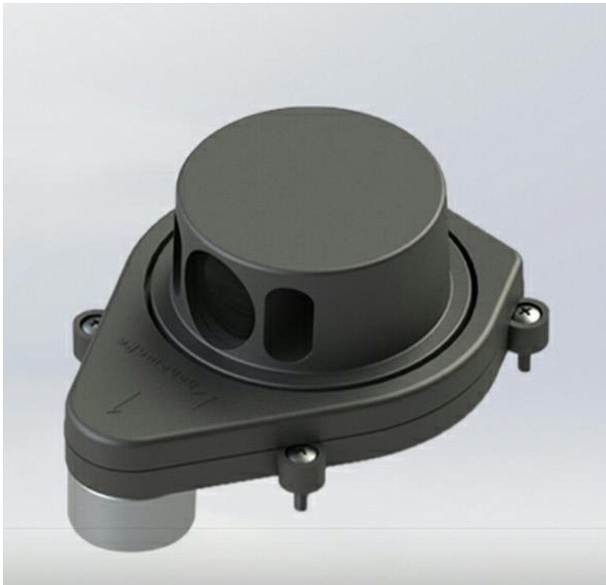


(Figure3: Border Coordinate)

The obstacle position will be returned by the RPLIDAR, it can be 360° no dead angle periodically scan obstacle.The angle of a circle is divided into four directions,front,right,back and left.When obstacle into the detectable range,it will return the value of one direction,ensure the aircraft can avoid obstacles in time.



(Figure4 Border Coordinate)



Besides above all of these, we also have some technology to research and we also need to test and adjust the current program. What we did and doing are all aim to close the seventh mission. There may be some change during the next preparation.

The end.