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# Design of Multi-UAV Coordinated Flight Monitoring System

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**Abstract:** A monitoring system that can be rapidly expanded is proposed, aiming at the application of the flight monitoring system in the ground control system under the background of multi-UAV cooperation. The system software is deployed in the same touch-hardening machine, and adopts a distributed screen display method by a combination of soft panel data prompts and physical location-based signal prompts to perform software deployment. The indicator light of the hard panel of the touch system, the data status of the hierarchical alarm network interface, the flight controller can take a real-time and effective response mode for the abnormal state; the hardware keys around the touch system through the serial communication protocol is received, and the controller can switch the monitoring software according to the task requirements. It shows the feasibility, superiority and expansibility of the system in the human-machine interaction system of the ground control station based on the static joint test.

## 1. Introduction

With the development of ergonomics of domestic UAV system ground stations, the design of UAV flight monitoring system has been continuously improved, and the construction of a reasonable flight monitoring system has become an indispensable part of the development of UAVs.

In the field of UAV development, civil small UAV air traffic control and military colony networking, multi-machine monitoring is the development trend of UAV monitoring. At present, most of the monitoring modes with multiple large screens displaying multiple UAV information are problematic.

On the one hand, the large-screen display system platform has high requirements for software design and screen hardware, and the platform has low scalability for multi-UAV applications. On the one hand, the operation requirements of the UAV operator are relatively high, relying on software data prompts for unmanned Monitoring of the machine, long-term operation will cause the visual fatigue of the operator ,this conditon is not conducive to safe flight , the UAV is not intelligent enough, for safety and reliability, too many control system parameters, the soft panel is prompted by text, not timely , effectively reminding the operator of the abnormal state of the UAV ,that will cause operator fatigue. On the other hand, the operation mode of the UAV's operation mouse depends on the soft panel, and the operation of the operator's mouse-based soft panel is slower in the case of multi-UAV network.

The flight display control system with touch operation reflects its advantages, flexibility, simple and fast operation, and powerful functions. It has become the mainstream trend of multi-unit network UAV monitoring system [1, 2, 3].

This paper proposes a flight monitoring system that can be rapidly expanded in the context of multi-machine collaboration. The system will be deployed on the distributed screen of the hardening machine, unified deployment of seat software, soft-faced version and grading alarm method combined with the panel. The operation interface is switched according to requirements, and the touch screen and mouse are combined. The hardware structure of this monitoring system facilitates the expansion of later multi-machines.

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## 2. Composition and working principle of the Flight monitoring system

### 2.1 System composition.

The flight monitoring system hardware consists of a touch hardening machine and a display screen. The software includes deployment software, monitoring software and data management software, wherein the monitoring software includes four major functional interfaces: flight, avionics, mission equipment and navigation. Interface includes serial port and network.

### 2.2 Working Principle of the System

Flight monitoring system, first software deployment. According to the mission of this flight, deploy the software through the monitoring system, and configure the monitoring machine number, physical location, and broadcast port number of the software. The monitoring system software starts successfully by clicking the Start Software button.

The system monitoring software receives the GOT (Ground Data Terminal) to transmit the telemetry data to the data management software through the serial port, the data management software is broadcasted to the monitoring software, the mode of the flight part receives the flight data, and the avionics module receives the avionics data. The task device portion module receives the task device data, and the navigation portion receives the navigation data. The monitoring parameters are displayed in real time, and the monitoring software uses a combination of touch screen and mouse to send control commands to the data management software through the broadcast protocol.

There are multiple function buttons around the display of the touch-hardening machine, which is responsible for switching the functions required for monitoring. The monitoring software is responsible for the display and control of the data, the data management software distributes the data, and communicates with the radio data terminal to finally realize the control of the aircraft. System interface schematic is shown in Figure 1.

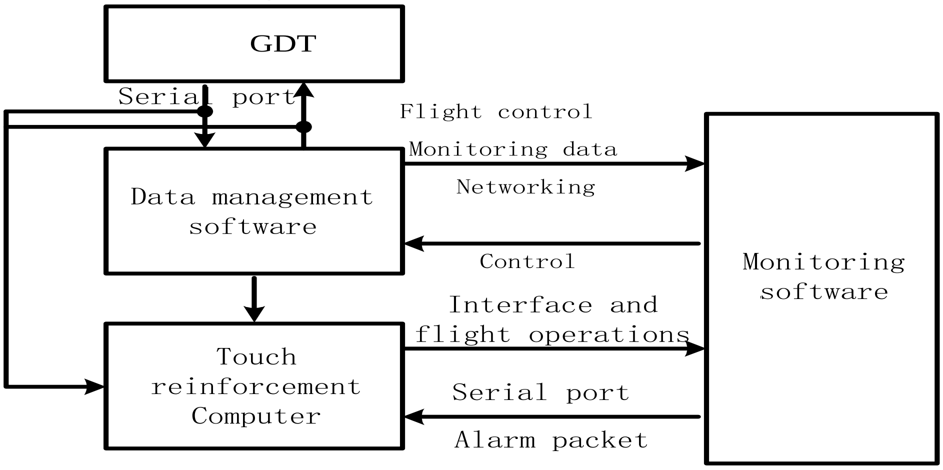


Figure 1. Interface Schematic of the Flight monitoring system

## 3. Design and implementation of the Flight Monitoring System

The monitoring software and the management software which is backend data form the software functions of the flight monitoring system. The two parts interact with the touch machine through the port which include with network and the serial port to form the entire flight display control system.

### 3.1 Hardware Design

The touch screen of the touch machine is a capacitive screen, which can support multi-touch. The buttons are black. There are 4 buttons on each side of the LCD screen. The serial port interface is used to directly connect the local motherboard. Using i5 three generations of processors, the memory can be 2G, and the power supply is an external AC220V to DC24V power module. Working Principle of the System.

### 3.2 Software Design

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#### 3.2.1 Software deployment

After the monitoring system is started, according to the requirements of this task, the aircraft number information displayed on the current screen of the manipulator is determined.

The monitoring software is implemented using Microsoft Visual C++ 2012 programming. The screen number is Z, the physical position is X, and the aircraft number is Y. The screen number physical position and aircraft number in the corresponding monitoring software program are S, Z, and P, S = Z, P = X, N = Y.

Using the three text box Edit controls in MFC, Sz, Px, Ny are binded the three variables, the result R of the binding is shown as following function:

$$Rz(S, P, N) = (Sz, Px, Ny) \tag{1}$$

$$(Sz, Px, Ny) = (Z, X, Y) \tag{2}$$

The software displays the corresponding control interface by the ShowWindow (TRUE) function.

#### 3.2.2 Monitoring method

The monitoring software is divided into flight, avionics, mission equipment and navigation from the functional interface. The monitoring parameters are implemented in the form of a combination of graphics and text. GDI (Graphics Device Interface) PLUS+ is used to draw the instrument. GDI is the graphic device interface [4, 5]. The main task is to exchange information between the system and the drawing program and process the graphic output of all Windows programs. Use GDI's many functions to easily output graphics and text operations on screens/printers and other output devices.

The monitoring function includes three parts, the first one is monitoring status fuction, the second one is the alarm function, and the third one is the Data management part. The following three parts are introduced separately.

1) Monitoring Status Function

Software and data management software uses network communication methods, binding sockets, and the network receives messages UM_SOCKET to receive network packets.

The following functions are used in the communication to receive the data from the net.

```
socket((AF_INET, SOCK_DGRAM, 0)                                    // define socket
bind(SourceSocket, (struct sockaddr *)&LocalAddr, sizeof(LocalAddr)) // bind socket
```

The flight data is received according to the network protocol, and the flight parameter variable is periodically refreshed in the OnTimer timer function. The parameters include two display modes, namely text printing and graphic refresh. Among them, the important flight parameters such as flight heading angle, pitch angle, roll angle and height are graphically displayed, which is relatively intuitive. “n OnPaint()” which is refresh function refreshs the graphic pointer ,then the graphic displays on the soft panel of the system to realize the parameter display. The following figure shows the display flow of the attitude parameter.

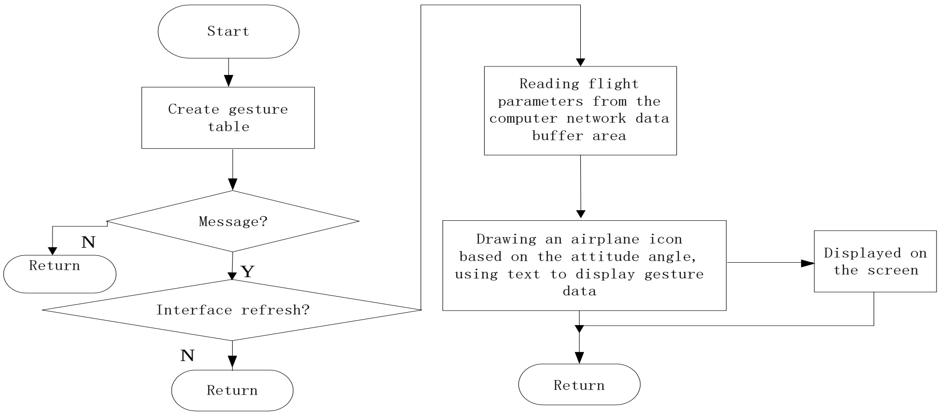


Figure 2. Parameter (attitude) display module working principle diagram.

2) Alarm Function

The alarm data of the software is sent to the serial port of the hardening machine through the serial port by the sio_iqueue () function according to the serial port alarm protocol [7]. The warning light is enabled, and the monitoring status is alarmed according to the alarm level. The classification is as shown in the following table.

Table 1. Alarm level description.

| Numble | Light Alarm | Light Position | Light Color | FlashPeriod |
|---|---|---|---|---|
| 1 | 1 | First left | Red | 1s |
| 2 | 2 | 213 | 644 | 4s |
| 3 | 3 | 654 | 649 | Always |

3) Data management Function

The function of the Data management is implemented in data management software. Programming with Microsoft Visual C++ 2012. It adopts PCOMM serial port control and broadcast communication mode, and is mainly responsible for data distribution, including serial port and network data receiving and sending. The data management software interface is shown in Figure 1.

### 3.2.3 Demand switching

The monitoring software is divided into flight, avionics, mission equipment and navigation from the functional interface.

Click the button signal of the peripheral button of the reinforcement machine to generate the data packet. The format is as follows in Table 2. It is sent to the monitoring software through the serial port. The serial port data is received through the PCOMM control. The enabled button number is determined according to the protocol, and the sub-function interface of the response is displayed.

Then the demand switching success flag R(x, y) is:

$$R(x, y) = (Bx, Sy) \tag{3}$$

## 4. Monitoring system expansion

If the system needs to fly multiple UAV at the same time, the ground control station does not need to redesign the hardened computer cabinet, design large resolution monitoring software to monitor all the UAV at the same time, and the monitoring system can load multiple hardening machines at the same time to realize multi-machine expansion, see our example below.

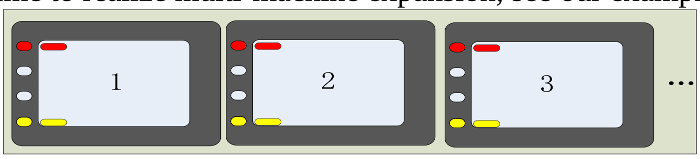


Figure 3. Extended system schematic.

## 5. Conclusion

The monitoring system under multi-machine collaboration, GDT plus+ and VC++ 2012 is used to develop monitoring software and data management software, the software communicates with the touch machine interface to realize the flight operation of the touch screen and peripheral button knobs on UAV. The software is deployed in a unified manner, and the function interface of the monitoring is switched according to requirements, and the alarm light is used for the hierarchical alarm. The modified display control system has been expanded and used in a certain multi-UAV system.

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