Research on Key Technologies of UAV Remote Sensing Operation Systems

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Abstract: Satellite and aerial remote sensing (RS) techniques have been provided to collect spatial data globally over the last few decades. However in developing countries such as China, there is still an urgent need for low cost and high resolution RS data. As an emerging RS platform, commercial Unmanned Aerial Vehicle (UAV) integrated with state-of-the-art sensors and information technologies has the potential to become a low cost tool to meet application demands. In this paper, the architecture of UAV RS operation system is mentioned. Moreover, key technologies in UAV RS system are analyzed and current work is reported.

Key words: Unmanned Aerial Vehicle (UAV), remote sensing (RS), information platform, spatial data, commercial operating system

1. Introduction

With the development of remote sensing (RS) in many fields, the demand for RS data is soaring dramatically. The data acquisition is still the major obstacle for the RS applications. Although many developed countries have the abilities to produce high resolution data according to the user's specific requirement, the supply of data is inadequate to meet the great demand in most developing and underdeveloped countries. Therefore, the aerial RS technology is developed rapidly as an important system to acquire RS data. Under the support of Chinese government, the aerial RS system and related technologies have been progressed rapidly in recent decades [1]. Unmanned Aerial Vehicle (UAV) RS system, which has many attributes such as low operating cost and flexible aviation planning compared with satellite and other aerial RS systems, is one of the important tools for data acquisition.

Based on the development for military purpose at the initial time, UAV has been gradually applied to many civil fields recently [2]. As the advent of light, small and perfect sensors for UAV, it is possible for UAV to serve as the flight platform of RS system. Nowadays, the UAV system has been applied to many fields such as military reconnaissance, maritime surveillance [3,4], environment protection and land monitoring.

In most cases, the UAV is not designed for the RS purpose, nor are the most sensors for UAV platform. As a result, their integration is difficult. In section 2, an UAV RS operation system with sensors, communication system and architecture is presented and key technologies are analyzed. In section 3, a conclusion is given for design and manufacture works in progress.

2. The architecture and its key technologies

2.1 The architecture of the operation system

The UAV used in RS is designed according to the manned aircraft standards and RS mission initially. With a cruising altitude of 5km, air speed of approximate 170km/hr, endurance of 30hrs and low cost, the UAV has the potential to serve as the RS platform. Under the normal weather, the flight smoothness error is lesser than $\pm 1^{\circ}$, and the navigational error or circular probable error are less than 50m。 The RS sensors equipped in the operation system include CCD or CMOS cameras and SAR. According to the UAV function, the architecture of the system is given as the figure 1.

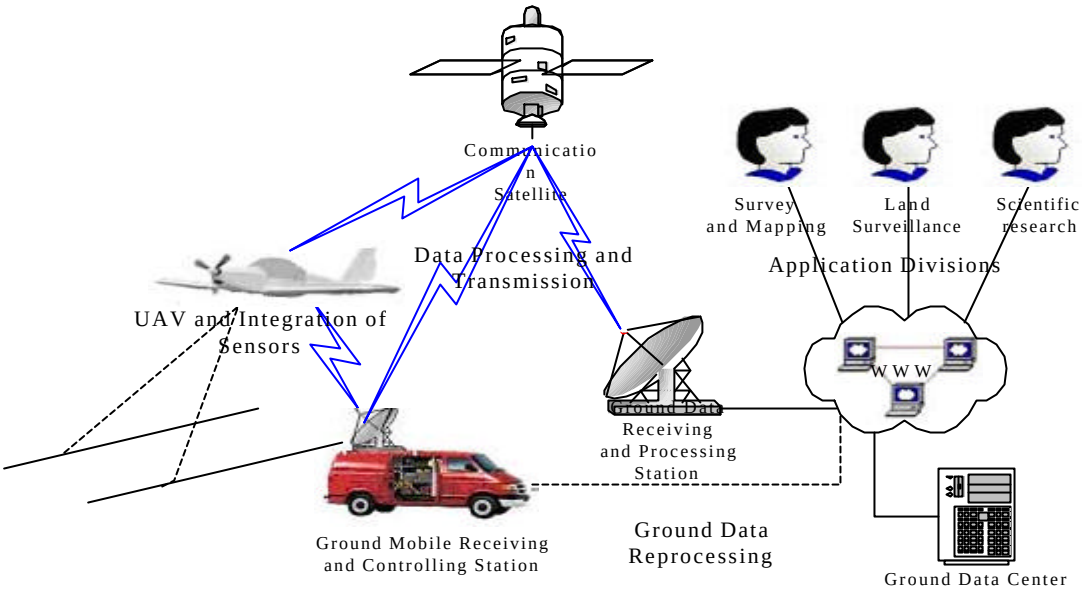

Fig. 1. The architecture of the UAV RS operation system

2.2 Key technologies in UAV RS operation system

1) UAV platform

The performance and cost of the UAV platform has a direct influence on the potential applications and RS results. Its characteristics depend on flight altitude, flight duration, payload, take-off and landing mode, and navigation accuracy. It is important to increase the performance price ratio of the UAV to ensure the continuable development of the UAV aerial RS system.

However, the conventional aerial RS system usually modifies the common plane to serve as the platform. The system performance will probably not satisfy RS mission demand. Therefore, a new kind of UAV with the manned aircraft standards is developed. As mentioned before, the UAV can be served as the platform of the RS system. The next work includes:

(1) To improve the key performance of the UAV based on the special requirement of the aerial RS.

(2) To develop more accuracy integrated navigation system based on the existed navigation system (GPS and INS).

(3) To develop the new version UAV before 2005 for RS work.

2) Integration of lightweight and high resolution remote sensors

Due to lighter payload of UAV, it is crucial that the platform allows integration for various types of light remote sensors. Moreover, because sensors are usually produced by different companies, the selection and integration of these sensors will be time-consuming and difficult. Therefore, it is key technologies for the establishment of the UAV aerial RS system to choose appropriate sensors to fit the UAV platform and specific mission, to develop the standard interface for different sensors, and to reduce the installing and adjusting time.

Now, the following works are being done to establish the system:

(1) To choose the suitable sensors among four kinds of high resolution Synthetic Aperture Radars (SARs) and two kinds of Charge Coupled Devices (CCD) optical cameras.

(2) To design the uniform interface for rapid replacement of these sensors.

(3) To install and adjust the sensors on UAV.

3) Real time processing and transmission of RS data from the UAV

It includes the technologies of real time data compression, data fusion, transmission, and relay communication for RS data.

The image compression and transmission are always the research focus in image processing field. Many new theories and methods have been applied to improve coding efficiency such as wavelet transform, fractal theory, and artificial intelligent theory. And many achievements have been made to resolve the conventional RS image compression by reducing the spectral correlation. However, the compression and transmission of UAV RS data has many special requirements due to the unique characteristics of the UAV: huge data volume, algorithm simple and easy to be implemented, adjustable compression ratio

according to different mission, and high transmission rate. Some successful schemes have been adapted to resolve the compression and transmission problems [5].

In the system, a program including lossless and near lossless compression is adapted. And the data fusion technology is used to improve the navigating and positioning accuracy. The communication system supports two ways of data transmission, the direct transmission and the satellite relaying transmission.

4) Receiving and postprocessing of RS data on the ground stations

It includes receiving data from UAV and processing them according to the users' requirement. The storage, management and dispatch of the mass RS data are also key technologies.

The high resolution of UAV aerial RS operation system will produce huge data in TB level. The continuable operation needs an efficient management system, which is responsible for the data receiving, storing, processing and dispensing. The works are as follows.

(1) To establish the fixed and mobile ground data station (as showed in figure 1).

(2) To establish a data center for huge RS data.

(3) To perform radiation correction in data center, including system and atmospheric radiation correction, frequency compensation and noise elimination.

(4) To perform essential geometric rectification according to the condition of UAV, sensors and circumstance.

(5) To perform accurate geometric rectification based on the ground control points.

5) Related standards

During the experiment, related standards are studied to establish the standards of UAV RS operating system in future. The research focuses on the standards for the hardware (such as UAV, interface and communicational equipments), software (such as software interface, architecture and data format), as well as evaluation and test methods.

6) Experiment to specific users

With the attribute of all-weather operating, low running cost, flexible planning and high resolution, the UAV RS operation system can be applied to many fields. On the basis of some key technology breakthrough, surveying and mapping experiment in Guizhou Province is being arranged to demonstrate the feasibility and validity of the design. The mission includes updating 1:10k topographical database, establishing 1:2k geographic information databases for major cities and land surveillance in important areas.

3. Conclusions

It is possible to realize the construction of the UAV RS operation system due to the rapid development of RS sensors and UAV technologies. In this paper, the RS operation system based on a special UAV is proposed. The system now is being experimented in the aviation base and will be applied to special fields. The further research will focus on UAV information platform, compression, transmission, and the postprocessing of the RS data. The success of the related technologies will make the commercial UAV RS operation system more practical.

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