Innovative Talents Training Practice based on Quadrotor Unmanned Aerial Vehicle Experiments

Mingjian Sun[1, a], Hai Du[1, b, *], Jianfei Sun[1, c], Yi Shen[2, d] and Liyong Ma[1, e]

[1]School of Information Sci. & Eng., Harbin Institute of Technology, Weihai 264209, China;

[2]School of Astronautics, Harbin Institute of Technology, Harbin 150001, China.

[a]sunmingjian@hit.edu.cn, [b, *] duhai6020@hit.edu.cn, [c]sunjf_70@126.com, [d]shen@hit.edu.cn, [e]maly@hitwh.edu.cn

Abstract. Experimental teaching is an important part of practical teaching. There are several problems in traditional experiments used to verify classroom knowledge. First, the contents are obsolete and too far away from the actual life of students. Second, the experimental equipment and content cannot meet the multi-level needs of different students. This paper discusses the practical experiment development process employing quadrotor unmanned aerial vehicle (UAV). The developed experiments in this paper not only can solve the problems existing in the current experiment course mentioned above, but also combine the simulation with the actual UAV system to meet the needs of the experiment course and the training of innovative talents. These beneficial successful practices can be used for reference in the construction of other experiments.

Keywords: Experiment course; unmanned aerial vehicle; innovative practice.

1. Introduction

Practice teaching plays an important role in the cultivation of students. It enhances the understanding of theory knowledge learned at classroom, links theory at classroom with practice, and improves solution ability to practical problems. It can avoid the separation of theoretical knowledge from practical activities. For a long time, there has been an emphasis on classroom teaching in higher education in China, but experimental teaching is ignored. Most teachers attach importance to the accumulation of knowledge and neglect the cultivation of practical ability. In recent years, with the steady progress of teaching reform and the requirement of innovative ability training and construction of new engineering majors, more and more universities and specialties begin to attach importance to the establishment and construction of practical teaching. However, there are still many problems to be considered and solved on how to build an effective and low-cost practice teaching.

Experimental teaching is an important part of practical teaching. And together with curriculum design and practical training, it constitutes a rich practical teaching. There are several problems in traditional experiments for the verification of classroom knowledge. First, the contents are obsolete and too far away from the actual life of students. So, students are not interested in them. Second, the experimental equipment and content cannot meet the multi-level needs of different students. Many experiments can only support the basic knowledge practice of classroom contents. They cannot meet the needs of students who need more resources to conduct in-depth research. And they cannot support the requirements of innovative research learning. Therefore, how to construct experimental courses for the construction of new engineering majors, how to cultivate innovative talents, how to teach with the student-centered method, these are all important issues that the current experimental teaching is facing. At present, there are not many practical processes of experimental development that can meet these requirements.

This paper takes electrical automation specialty as an example to discuss the practical process of using quadrotor unmanned aerial vehicle (UAV) system to set up experimental courses. The experiment course not only can solve the problems existing in the current experiment course mentioned above, but also combine the simulation with the actual UAV system to meet the needs of the experiment course and the training of innovative talents. This experimental development has enlightenment and reference function for the development of experiment and practice course.

2. UAV Experiments for Electrical Majors

Electrical majors include varieties of majors, such as electronic engineering, automation, measurement and instrument, electrical engineering, etc. In these majors, circuit, digital electronic technology, analog electronic technology, embedded systems and so on are basic courses. It is a challenging task to design a comprehensive experiment for the content training of these courses, attracting most students, meeting the needs of different levels of experiments. In recent years, we have carried out the experimental construction practice of innovative talents training in Harbin Institute of Technology, Weihai campus. We set up a comprehensive experimental course which uses low-cost quadrotor UAV and combines simulation with real vehicles. The characteristics of the experiment are summarized as follows.

First, the experiment has enough attraction for students. Most students are interested in experiments and willing to participate in practical activities. Most students have dreams of flying on wings when they were children. UAV experiments can make some of these dreams come true and arouse the interest of most students.

Second, the experiment is carried out by combining simulation with real object. In the experiment, the Simulink simulation software in MATLAB is used to build the complete model of system measurement, control and data acquisition, which can carry out the simulation of data analysis, processing and control of various sensors. At the same time, the data processing and control algorithm designed by simulation can be directly written into the embedded system of UAV for actual flight test. On the one hand, the combination of simulation and real-world model solves the problem that pure theoretical simulation cannot support the implementation of the actual hardware system. On the other hand, this combination mode also solves real problems, such as hardware vulnerable to damage, being difficult to measure, track and analyze data in the direct development and testing of real hardware. And this combination mode improves the convenience of debugging in the innovative design of algorithm, thus saving developing time and improving the efficiency of developing.

Third, the experiment system can be used to set up experiments for different needs of students. These experiments can include at least the following contents: basic experiments supporting the basic measurement and control of UAV flight, advanced experiments using vision for navigation, innovative research experiments combining artificial intelligence and computer vision.

The experiments adapt Mambo FLY UAV product of Parrot Company in France. Its core processor is a 32-bit processor of ARM Cortex A8. The product is also equipped with a wealth of sensors, which includes 3-axis gyroscope, 3-axis accelerometers, 3-axis magnetometer, pressure sensor, ultrasound sensor and video camera. It is also equipped with four brushless motors. This UAV supports online programming and can be connected to the developed laptop via Bluetooth or wireless network. The laptop can run Windows or Linux operating system to develop for this UAV through the Simulink of MATLAB software [1, 2]. The UAV weighs less than 70g and is portable. It can be tested indoors and outdoors. In addition, the UAV and software also support 3D simulation in MATLAB. As shown in Figure 1, it provides a 3D simulation environment for takeoff and flight test. When the simulation is successful, the software can be downloaded to the actual aircraft for testing, saving development and debugging time. In the next section, we will introduce these experiments in more detail.

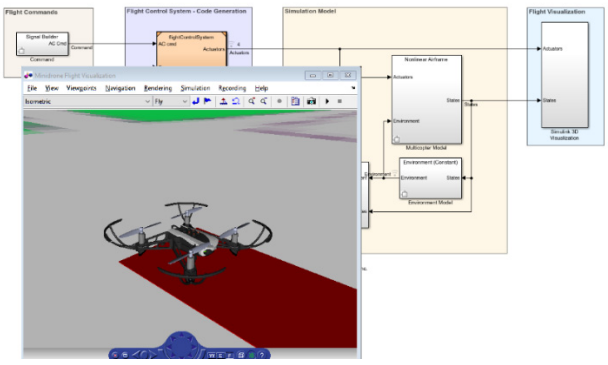

Fig. 1 Model simulation development and flight simulation of USV experiment

3. UAV Experiment Contents for Innovative Talents Training

An important feature of the UAV experiment we developed and constructed is that it can meet the requirements of different levels of experiments and serve the training objectives of different types of talents. The level that the experiment needs to satisfy should include at least three layers, which include basic curriculum experiments that are suitable for the basic knowledge of the course, more complex practical experiments that can meet the requirements of the comprehensive training of the course, and experiments for the training of innovative engineering application talents.

3.1 Basic Experiments Supporting the Measurement and Control of UAV

Embedded system development experiment is the basic experiment provided by UAV, which supports the learning of the basic MCU development and debugging process. The experiment also provides the data collection and analysis training for all kinds of sensors equipped by UAV, which are important training contents in circuit, electronic technology, sensors and other courses. Especially, different kinds of triaxle sensors provide abundant experimental contents for data acquisition and analysis.

Automation specialty is a general electrical specialty in China. Its core specialty course is automatic control theory. The UAV experiment designed by us can provide basic experiment for the course of automatic control theory. These experiments include control system modeling and identification, control system simulation, control system design, digital control and so on, which provide necessary support for the course content. Taking PID control in control theory as an example, PID algorithms for the position and attitude control loops are designed respectively to enable the USV to fly along a predetermined route [3].

3.2 Advanced Experiments Using Vision for Navigation

Because USV has cameras, it can carry out various vision-based navigation research. These contents involve the combination of image processing, computer vision and control theory. Two typical experiments can be carried out. The first one is to carry out the experiment of visual-based target tracking flight with the help of images captured by cameras [4, 5]. Typical applications are tracking objects with bright colors or fixed shapes. Specific colors are recognized by color space transformation, specific shapes are recognized by edge detection and Hough transformation. Sometimes combining colors and shapes are used to recognize objects and track them. The second is the landing experiment. Like the study of target tracking flight, the landing position is determined by shape or color or a combination of the two, and the landing action is implemented.

3.3 Innovative Research Experiments Combining Artificial Intelligence and Computer Vision

The USV experiment described in this paper supports the development of innovative research experiments. The first is the advanced control algorithm for USV flight and control. The second is the applications of artificial intelligence and machine vision.

Many advanced algorithms can be used in UAV flight and attitude control, such as various improved PID algorithm, predictive control algorithm and so on [6]. When multiple UAVs are used, algorithms for formation and control of UAVs can be studied. These are very good innovative experimental contents at present, and easy to attract students' interest and attention, they are also willing to carry out these experimental studies.

In recent years, the field of computer vision and artificial intelligence has developed rapidly, especially the emergence of deep learning technology, which has brought about a leap in visual processing technology. As a successful machine learning technology of artificial intelligent, deep learning can be introduced into USV video processing, bringing many interesting and innovative results and applications. For example, face recognition technology is used to locate the face and select the appropriate location to take photos, human recognition is used to track flight, and gesture recognition is used to carry out flight performances [7, 8]. Due to the limitation of the computing power of embedded system in USV, the current artificial intelligence video processing methods are

usually completed in notebook computers. Video images are received by communication with USV. After processing, the results and instructions are sent to USV to complete the task. A team is currently developing in-depth learning modules to implement these functions on USV.

4. Summary

In view of the main challenges and problems faced by the current experimental courses, this paper discusses the practical process of using 4-rotor UAV to set up electrical courses in order to cultivate innovative talents. The experimental courses developed can attract the interest of most students and meet the requirements of different levels of experiments, and it combines the simulation with the actual UAV system. The successful practice of these experimental designs can be used for reference in the construction of other experiments.

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