Hardware and software complex of intellectualized orientopter-type systems

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Abstract- The problem of the development of a miniature, cost-effective, unmanned aerial-terrestrial ornithopter for military applications is considered. Solutions from leading foreign and domestic companies and research laboratories on the design and testing of aircraft systems are analyzed. The hardware complex was built as a small-sized ornithopter using state-of-the-art electronic components such as the Ardupilot Mega 2.6 chip and GSM module to provide autonomy and orientation in space capability. By increasing the load capacity of the device, it is possible to install additional modules, in particular a photo or video camera and an OSD module that will allow you to overlay the telemetry settings on the image transferred from the camera. Controlled stable hovering will minimize the negative impact of vibrations that arise during the model's wings movement and save battery life.

Keywords - unmanned aerial vehicle, design, hardware and software complex, microcontroller, ornithopter.

Introduction

In an unstable and security-oriented environment, developers are increasingly focusing on the use of defense-based technologies based on small, remotely-managed mobile platforms or can be programmed for autonomous use without the immediate presence of a person within a range of combat activities or on the territory, which monitoring should be carried out [1].

In the field of defense, real-time observation from a close distance has long become an important necessity, which contributes to the study of various methods of "live" communication on the battlefield to provide the necessary support to the troops. For this purpose, unmanned aerial vehicles (UAVs) are often used - miniature devices that follow the flight, in particular birds.

These aircraft are ideal platforms for a variety of tasks, including monitoring and control systems, where the tidal fleet "flock" will be invisible and will have better access to inaccessible places than large aircraft. These systems are widely used in the field of defense during intelligence and surveillance of enemy territory without the detection of the device and without causing suspicion.

Usually real UAV developments include a microcontroller, a set of sensors for determining the required parameters and a surveillance camera for transmitting video information to the receiver in real time. Important attention is paid to optimization of load-carrying capacity, stability during an accident and the ability to repair in field conditions. Thanks to miniaturization of electronics and the emergence of new composite materials, commercial companies, military units and research laboratories are working on the development of numerous unmanned machines and entire platforms for their research and implementation [2].

The most widely used propeller vehicles and fixed wing vehicles. However, these devices have a number of disadvantages and are expensive. Along with them the distribution of other types of devices with non-standard approaches to the construction and working principles. Such devices are UAVs like ornithopters, which use wing swings to create lift and traction forces. Small ornithopters using wing wings to create aerodynamic forces have a number of advantages over fixed and propeller wings. They are safe to operate because they do not have rotary parts and fuel tanks. It is assumed that by simulating the agility and agility of living flying creatures, ornithopters can be multi-purpose UAVs.

The aim of this work is development of own model of the hardware and software complex of UAV ornithopter-type systems using the Ardupilot Mega module and GPS to provide autonomy and orientation in space, as well as the development of flight modes of the ornithopter software.

Results and Discussion

In the projected UAV, all elements of the system are connected to the Ardupilot Mega 2.6 chip. The selected platform is positioned as a flight controller, which includes both a regular microcontroller and a fully-fledged autopilot.

Ardupilot is based on ARM 2.x (DIY Drones), the project contains open source code. The control board combines not only the computing power to control the controllers of engines or servo drives, but also a set of sensors (accelerometer, gyroscope, barometer), based on which indications can be adjusted flight algorithm. The advantage of the board is the availability of autopilot function, which allows the machine to move independently on the given trajectories without external intervention. Various configurations can be used to connect an APM autopilot. In this paper, an airplane type connection is used, which allocates channels for controlling the power plant (Turnigy 2615 EDF Outrunner) and servo drives (Hitec HS-65MG) that are responsible for the control surfaces (elevators, elephants). Used configurations using model of elevator, ailerons and stub and only elevators.

In the developed ornithopter model, the main control surface is the tail, which can control pitch movement up and down and mixed control - a combination of tail movements from side to side, along the axis of the roll, and up and down for dislocation (the hybrid elephant is realized).

Two models of servomotors are used to control the direction of the model, one of which (for controlling the elephant) will bend along with the tail while moving up and down. The servo drive on the pitch is fixed on the fuselage, and for the board on the roll - fixed on a frame that comes back along with the tail.

On the lever of this servo, the tail is fixed with two screws. In addition, in this model we implemented the principle of a flexible wing. The fuselage has a fixed movement mechanism (engine, gearbox and two cranks), from which traction with ball pointers goes to the front edges of the wings. Also, in the mechanism of the swing of the wings provides for the possibility of securing a certain position to ensure the planar flight of the ornithopter as presented in [3].

The electric motor through the two-stage gear reduces the movement of the wings. The configuration connection is organized in such a way that the inputs of the autopilot cards are connected to the four ports of the radio signal receiver. One of them is used to control the engine's turns, the second one - to choose the flight mode, and two more - to control the servo drives. Structural and functional connection diagrams are shown in Fig. 1 and Fig. 2, respectively.

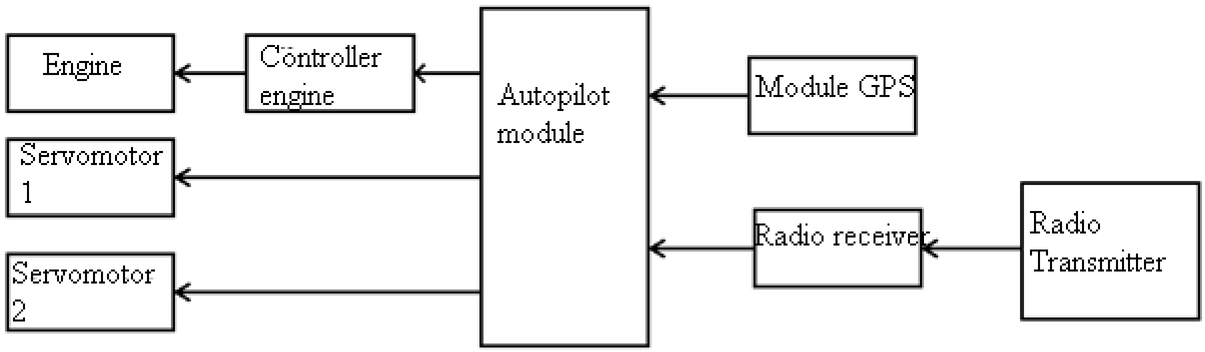

Fig. 1. The block diagram of connecting the main elements of a projected UAV ornithopter-type.

Autopilot outputs are connected to the servo drives and to the motor (via the ESC circuit - the speed controller). Power is fed through the controller of the revision at the same time on all elements of the system. Also, the GPS module is connected to the corresponding port. The module itself autopilot is mounted on the fuselage. To recognize autopilot the directions of motion and correct positioning, it is mounted on a special stand to reduce the negative impact of vibrations on gyroscopes and accelerometers.

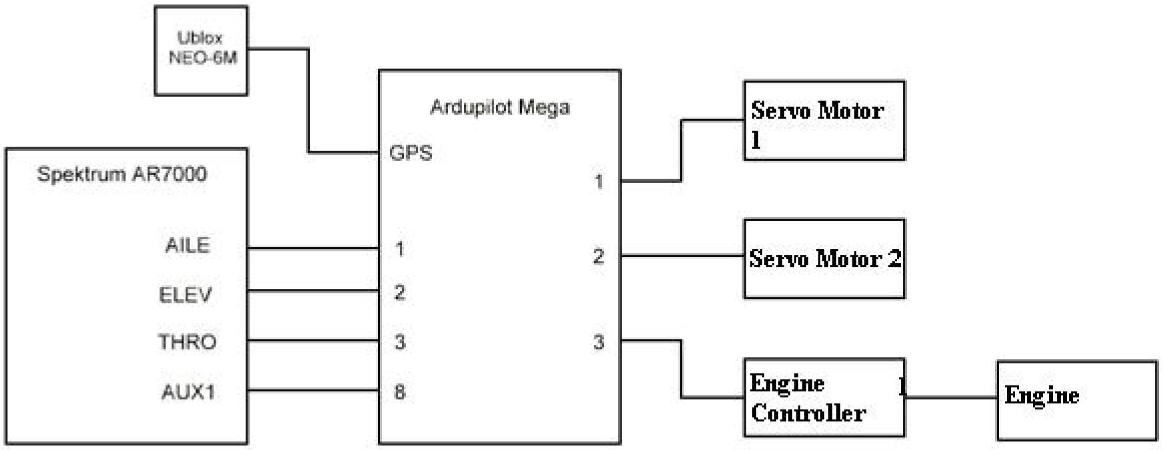

Fig. 2. Functional scheme of connecting the main elements of a projected UAV ornithopter-type.

With this configuration, one of the levers of the control panel will be responsible for controlling the speed of the engine and, accordingly, the speed of the model, and the second - for managing the servo - that is, the direction of movement of the device. One of the available switches will be responsible for switching flight modes.

The work of the designed ornithopter can be arranged in 12 modes of work available for this software, both for manual, and for autonomous control of the device. In this work, the Mission Planner worked out manually, Stabilize, Stabilize, RTL, and AUTO points (Fig. 3).

The configuration and programming of the board is implemented with the use of the Mission Planner [4], which additionally allows you to change the sensor display, build a flight plan, simulate flight for manual control skills, view the so-called "logs" (a separate memory chip in the board). for "logging" of flight data, so-called "black box"), etc.

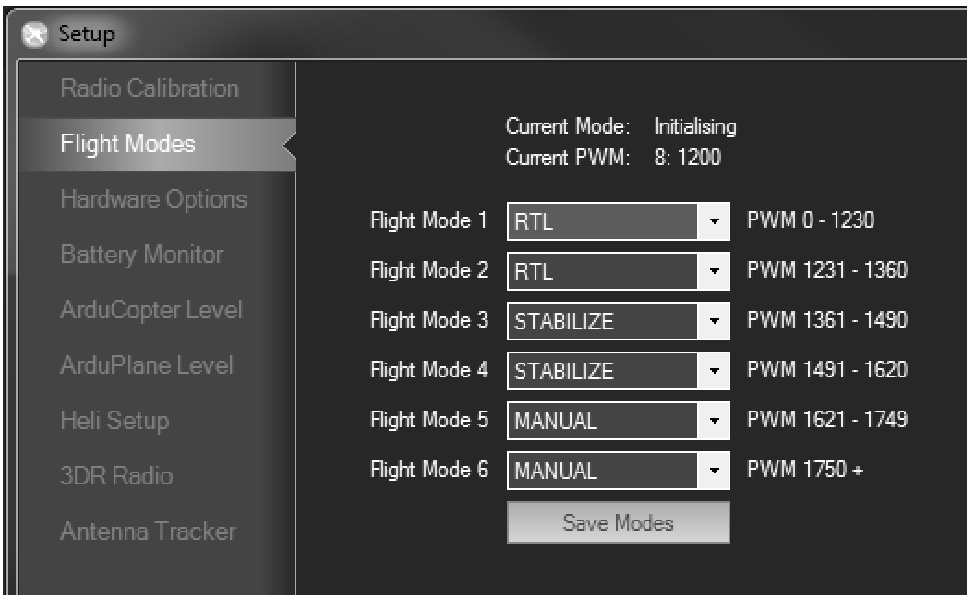

Fig. 6. Configure the flight modes of the ornithopter.

Switching modes was implemented with the switches on the remote control (transmitters) [5]. A certain position of the switch is brought in a certain mode. It is also possible to switch modes through a ground control station - a computer, for this it is mandatory to install a radio modem module, the availability of which will allow not only to switch modes, but also to obtain telemetry data (Fig. 4).

Fig. 4. Receiving telemetric data by the Mission Planner program, fixed by the projected ornithopter.

Conclusions

Thus, the hardware-software complex developed in this paper - a small-sized UAV type of ornithopter can be used to monitor the territory of both military operations and areas of civilian significance. By increasing the capacity of the device, you can install additional modules, such as a photo or video camera and an OSD module, which will allow you to apply telemetry parameters to the image transmitted from the camera. Controlled stable hovering will minimize the negative impact of vibrations that arise during the model's wings and save battery life. Changing and optimizing autonomous flight modes can improve handling and enhance the functionality of the ornithopter.

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