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TELEMETRY SYSTEM OF UNMANNED AERIAL VEHICLES

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Abstract**—*The article is devoted to the design of unmanned aerial vehicles telemetry system software based on MAVLink protocol. Telemetry systems are necessary for most of the unmanned aerial vehicle types even with small operating range to inform operator about restricted areas and battery charge. More advanced unmanned aerial vehicles must also report piloting and navigation parameters, route details and current task progress parameters. It requires unmanned aerial vehicle to use special hardware and software equipment so it is necessary to make it energy effective. This problem can be solved using package data transmission protocols.*

Index Terms—Telemetry; unmanned aerial vehicle; MAVLink; message package.

I. INTRODUCTION

Nowadays unmanned aerial vehicles (UAVs) are widely used in different areas of life. They vary greatly by size, action range, load capacity, flight time, etc.

An unmanned aerial vehicle is a flying machine that boasts a take-off and landing without a pilot on board. They are widely used in the military sector, primarily for intelligence in the air.

Depending on the principles of control, there are the following varieties of unmanned airborne systems:

– unmanned and unguided;
– unmanned automatic;
– unmanned remotely manned aircraft (UAVs).

In the aviation after 2000, there is a rapid expansion of the very latest type of apparatus, and they are referred to when the term "unmanned", "drone", or abbreviation UAV is used. That is, the term "unmanned", "UAV", "UAV" means the aircraft that is controlled by one or more pilots through communication channels. The UAV crew may also include a commander, a sensor operator, an operator of firefighting equipment.

Further development of many areas of human life requires the use of modern technology and equipment that saves resources and improves production efficiency. That is why we have choosen the quadcopter machines as the object of our work.

II. PROBLEM STATEMENT

Unmanned aerial vehicles are widely used in military applications, primarily for aerial intelligence – both tactical and strategic. Drones of mini- and micro-subclasses are increasingly being used during platoon combat operations and in the area for urgently receiving information such as "what is behind that hill", that is, to solve military intelligence tasks.

In addition, nonmilitary drones are used to solve a wide range of tasks for which piloted aircraft for various reasons is inappropriate. Such tasks are:

– monitoring of airspace, terrestrial and water surfaces;
– environmental monitoring;
– air traffic control;
– control of maritime navigation;
– development of communication systems;
– artistic photography.

Use of UAV allows the following tasks:

– operational monitoring of fields with tens and hundreds of meters high;
– identification of problem areas that can not be made by traditional methods;
– quality control over the implementation of sowing, soil cultivation;
– quality control of agricultural machinery;
– field measurements taking into account the terrain, with high precision and Global Positioning System (GPS) attachment;
– counting the ladder and biological yield.

All these tasks include the information transmission to drone operator so it is necessary telemetry systems which must provide the necessary signal transmission quality and efficiently use the limited energy resiurces of UAV.

III. PRINCIPLES OF TELEMETRY

A special module, designed to output information about the state of flight from the UAV to the control panel or screen, received the name telemetry for a quadcopter [1], [2]. This modern trend is gaining popularity every day, as it is possible to track the motion of a dron in real time, to see what is now in front of the camera device. Telemetric systems are designed to broadcast parameters from the on-board camera of the copter to the computer, glasses, phone. Depending on the type of system used, several modules are installed:

– dedicated – uses its sensor set, screen and signal transmitter;

– built-in – information is transmitted using the protocol of the remote control;

– OSD – output data directly to the broadcast video.

– installation of a two-way modem – one part remains with the pilot, the second one is connected to the flight controller.

IV. TELEMETRY AND OSD

The telemetry system is intended for the information transfer from the board of important technical information in real time, as well as, if necessary, the recording of this information in the log for further study. The composition of this information depends on the purpose of the system and the needs of the operator. In the simplest case, when the flight takes place at a short distance and the copter is monitored visually, it is enough to accurately monitor only the voltage of the power batteries. In a flight with the control of the camcorder already, as a rule, it is necessary to control the range of flight and the level of the radio signal, so as not to lose connection, as well as monitor the voltage of the battery of the video channel. In practice, the set of telemetry information is much wider, and it tries to include a maximum of parameters. Of course, the set of these parameters is determined by the equipment of quadcopter:

– voltage of the batteries;
– current consumption;
– battery temperature;
– flight controller operating mode;
– flight time;
– height;
– linear velocity;
– vertical acceleration;
– indication of accelerometers (roll);
– compass indication;
– engine speeds;
– current GPS coordinates;
– the number of satellites available;
– range to start point and direction "home".

Data has different practical value. For example, real-time engine speeds are only needed for debugging and tuning. if one or two motors work at a higher load at a time when the copter hangs horizontally and motionless, it may mean an imbalance of the copter – the displacement of its physical center of mass toward one another.

Most modern telemetry systems can independently handle the indicators of current sensors, voltage and temperature, as well as the flow of GPS data. There is no fundamental difference in where to connect the sensors, but sometimes it is constructively more convenient and safer to connect them directly to the telemetry module. On the other hand, there is no need to buy a very expensive logging and telemetry module, equipped with its own barometer, compass, accelerometer, since these sensors are still on the board of the flight controller.

In general, the computer system of telemetry consists of the following components: a set of sensors and other sources of information; an on-board telemetry module that processes the output data and "packages" them into a continuous data stream; radio channel for data transmission to the ground; device for receiving and displaying data; data logger device.

In the practical implementation of telemetry, different options are possible. In the classical and simplest scheme, data collection and processing is carried out by the flight controller. Further, through the serial port, it transmits the data stream to the special OSD module (On-Screen Data – will be discussed below), which superimposes numeric characters and graphic elements on the image of the on-board video camera, which is displayed on the ground in operator video glasses or on the display. Sometimes the current and voltage sensors and the GPS receiver are connected directly to the OSD module.

Data logging can be carried out in the built-in memory of the flight controller, in the memory of the telemetry module, in the special logger, in the ground computer or by recording the flight video. Log is useful in analyzing the maximum current consumption, searching for drains of the supply voltage, identifying the problem of the control channel, etc.

Telemetric information can be transmitted directly from the flight controller using a special radio modem – equipment that provides two-way UART communication through the radio channel.

And, finally, telemetry can be transmitted to the ground with the help of two-way radio control apparatus, with the presentation of data on the control panel display. This option is convenient, but not the cheapest, especially if you consider that for the flights on the camcorder still need telemetry on the screen.

The final choice of option and practical implementation depends only on the needs and capabilities of the owner of the copper, so one can not definitely say what's better.

The use of telemetry makes it possible to find out the copter distance from the take-off location, speed, flight mode, the number of GPS transmitters in the field of view of the unmanned aerial and so on. In this case, not only the control of the characteristics of motion, but also turns amazing beauty of shooting surrounding landscapes.

In order to benefit from the use of UAVs, their developers should provide the aircraft with the software part. Thanks to which it would be easy to operate the machines, send tasks, collect and receive intelligence information, and also return them to the point of launch whole and intact, for reuse. That is why telemetry channel software is vital.

The most effective way to ensure the reliability of radio channels is the use of broadband, whose performance is based on noise-like signals. Their main advantage is the noise immunity, high throughput. Existing methods for using such signals in anti-jamming systems can be divided into two categories: firstly, the inclusion of expanding code sequences, replacing elementary symbols for long sequences and other structures, and, second, the use of time-hopping carrier frequencies in accordance with the law, similar to the random one - this is called the pseudorandom processing mode modification of the operating frequency. Broadband signals differ in that their band of frequencies F exceeds the information rate of bits/s.

The second necessary component, without which it is possible to avoid the synthesis of broadband signals, is a pseudorandomity of the signal. The main physical indicator of signal quality is the signal-to-noise ratio at the output of the correlation receiver, and to improve this parameter, it is necessary to reduce the frequency or energy efficiency of the communication system by artificially increasing the signal base.

V. Message Transmission with MAVLink

MAVLink or Micro Air Vehicle Link is a protocol for interacting with unmanned aerial vehicles. It is distributed under the LGPL license as a module for python and library generator for a variety of programming languages, including header-only C / C ++ libraries [3]. The protocol [4] describes the information interactions between systems, such as MAV and GCS (Ground control station), as well as their components. The basic MAVLink entity is a package presented in the Fig. 1.

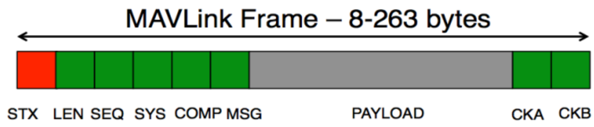

Fig. 1. MAVLink message frame

The first byte of the packet (STX) is the start signal symbol: 0xFD for version v2.0, 0xFE for version v1.0, 0x55 for version v0.9. LEN is the length of a useful message. SEQ – contains a packet counter (0-255) that helps us figure out the loss of a message. SYS (System ID) is the identity of the sending system, and COMP (Component ID) is the sender ID of the sender. MSG (Message ID) is the type of message that depends on which data will be stored in the payload of the packet. PAYLOAD - the payload of a packet, a message, 0 to 255 bytes in size. The last two bytes of the package are CKA and CKB, the lower and upper bytes respectively contain the package checksum. The MAVLink library allows you to encrypt and decrypt packets according to the protocol, but it does not regulate which hardware and software data will be sent. The library processes the input data byte, adds them to the buffer and itself collects a package from them. Each system or component can simultaneously exchange data from different sources, then a special identifier, called a channel, is assigned to each source. MAVLink contains a buffer for each channel.

VI. Displaying and Processing UAV Spatial Position

MAVLink has different built-in message types, and there is also the ability to add your own. In fact, what data are considered by the flight, which messages are sent periodically, and which only on request solves the flight controller. MAVLink does not declare what messages to use, we ourselves in designing our systems decide what messages our software will process [3], [4], and which – to send. For various flight controllers, dialects are provided that differ in the implementation details: the composition of messages or data, for example, modes. The root of the header-only C / C ++ library of MAVLink is the directories that correspond to the common dials.

We have reviewed some common messages that should be implemented in most flight controllers and ground control stations (GCS), and the change of dialect should not affect the code performance. The Vehicle class will serve as a model of the domain, which will aggregate the flight data for each MAV, and the VehicleService service will allow you to request / create Vehicle for systemId.

Diagram of MAVLink classes is shown in Fig. 2.

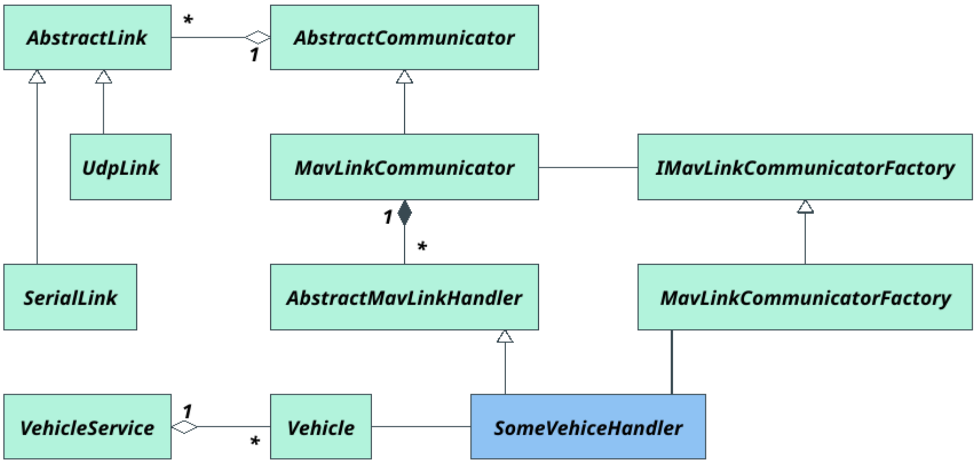

Fig. 2. Diagram of MAVLink classes

The ATTITUDE message describes the turning position of the MAV (drone) with respect to its center in space – the pitch, the angle, and the angles. Like the HEARTBEAT message, echoing from the abstract reporting class (AbstractMavLinkHandler), decode the package and get our data – the corners of the roll, pitch and rust. From the message we receive the systemId of system that sent us our message, and we can compare for which Vehicle need to update the data.

Similarly, we will write a handler of packages of the type VFR_HUD, in which grouped parameters are usually displayed on the indicator on the windshield. These parameters include MAVLink: air speed, track speed, altitude, speed, direction and gas (throttle).

The position of the UAV in space can be determined using a local or global positioning system. This data is transmitted by the protocol in messages of type LOCAL_POSITION and GLOBAL_POSITION, respectively. These packages are already processed, filtered. For GPS sensor readings, GPS_RAW and GPS_STATUS packages must be processed. To handle the position package, add the PositionHandler handler, and GPS for GPS data packets – GPSHandler. Processing of other common types of packages is carried out according to the same principle. Flight controller sends us packets with a certain frequency, which it defines itself, based on the settings, the speed of the data transmission or the type of communication channel. However, the frequency of sending any data can be requested manually by sending a message MESSAGE_INTERVAL indicating the ID of the message and the interval in microseconds.

VII. Testing Results

When write handlers for all types of packages are written, it is possible to fill model (Vehicle class) with data. Upon updating the data, the model will alert the view through the system of slot signals Qt. In order to reproduce the presentation (or any other action) did not pass several times when processing the same package, the data in the model are grouped into a structure (class), mirroring the contents of the package or logical content. Since new types will be used as signal arguments and Qt slots, they must be registered in the Qt meta-object system using the qRegisterMetaType function. And in order for these data structures to be available from the Qt Quick View (QML), we will add in their description the macro Q_GADGET. The Attitude class, for example, will group the turning position (Fig. 3).

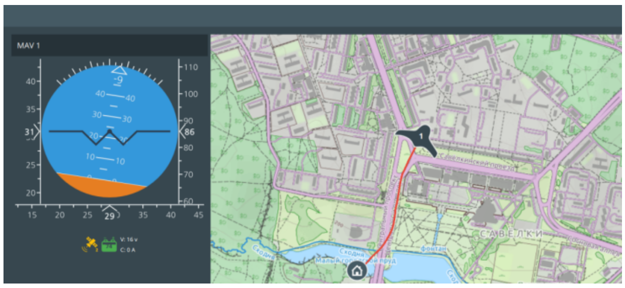

Fig. 3. Telemetry software operation in emulator

VIII. Conclusions

According to the results of the analysis of literary sources, it is established that "unmanned aerial vehicle" is the only one that is under the constant remote control of the pilot or pilots and is intended for returning to the aerodrome and for further re-use.

As the main telemetric parameters, the angles of pitch, roll, pitch, height and distance to the starting point are selected.

Based on the analysis of the existing concepts of the construction of telemetry systems, the concept of packet telemetry was chosen, which allows to provide high reliability of the data transfer with preservation of their initial sequence.

Using the classes of the library MAVLink developed the program code of the main function of the flight controller. It provides for receiving current information about the UAV operating mode, the angles of inclination, the distance from the launch point, the altitude, the battery charge, as well as the implementation of the mission – the flight of the specified coordinates at a certain altitude with a given speed.

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М. П. Василенко, І. С. Карпюк. Система телеметрії безплотних літальних апаратів

Статтю присвячено розробці програмного забезпечення телеметричних систем безпілотних літальних апаратів на основі протоколу MAVLink. Системи телеметрії необхідні для більшості типів безпілотних літальних апаратів навіть за невеликого робочого діапазону, щоб інформувати оператора про обмежені зони та заряд акумулятора. Більш просунуті безпілотні літальні апарати також повинні повідомляти про параметри пілотування та навігації, деталі маршруту та поточний прогрес виконання завдань. Для цього безпілотний літальний апарат потребує спеціального обладнання та програмного забезпечення, тому необхідно зробити його енергоефективним. Цю проблему можна вирішити за допомогою пакетних протоколів передачі даних.

Ключові слова: телеметрія; безпілотний літальний апарат; MAVLink; пакет повідомлення.

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Н. П. Василенко, И. С. Карпюк. Система телеметрии беспилотных летательных аппаратов
Статья посвящена разработке программного обеспечения телеметрической системы беспилотных летательных аппаратов на основе протокола MAVLink. Телеметрические системы необходимы для большинства типов беспилотных летательных аппаратов даже при небольшом рабочем диапазоне, чтобы информировать оператора о запрещенных зонах и зарядке аккумулятора. Более совершенные беспилотные летательные аппараты должны также сообщать параметры пилотирования и навигации, параметры маршрута и текущий прогресс выполнения задачи. Для этого беспилотный летательный аппарат требует специального оборудования и программного обеспечения, поэтому необходимо сделать его энергоэффективным. Эта проблема может быть решена с использованием пакетных протоколов передачи данных.
Ключевые слова: телеметрия; беспилотный летательный аппарат; MAVLink; пакет сообщений.

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