DEVELOPMENT OF A VIDEO STREAM TRANSMISSION SYSTEM IN DIGITAL FORM FOR FPV UAVS

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Annotation: The aim of the work was to study video data transmission systems used in UAVs and to develop and test the operation of a digital video stream system for use on UAVs of various types.

Key words: UAV, video stream, digital data transmission

To control the flight of a remotely controlled UAV, the operator needs to receive a video stream from the camera. The control method, when the operator sees the picture from the UAV's course camera from the first person, is called FPV (first person view).

There are two types of FPV systems: analog and digital (or HD - High Density). The difference between digital and analog systems is the type of signal. An analog system works by continuously changing the amplitude or frequency of a wave, while a digital system first encodes it into ones and zeros before sending it.

The analog system is the oldest, most affordable, and most common technology, available in 5.8 GHz, 2.4 GHz, and 1.2 GHz. In contrast, digital technology, which provides excellent image quality, is newer and gaining popularity [1]. Digital technologies are expected to become mainstream soon. In addition, it should be noted that when working with digital video transmission systems, it is possible to add artificial intelligence systems that can allow the operator to implement certain functions (for example, search and analysis of objects in the frame), and with further development, we can even talk about the implementation of an autopilot.

There are currently three commercial digital FPV drone systems available, all of which are 5.8GHz systems, and none of them are compatible with each other as they are all proprietary systems. The most famous commercial digital systems: DJI, HDZero and Walksnail Avatar.

Analog FPV is the original technology that started FPV drones. This technology has not been proprietary to any specific company for decades, allowing anyone to build components for the system. So, this is the most common system on the market. The DJI Digital FPV System is the pioneer and gold standard in digital FPV systems, known for exceptional video quality and reliability.

Before HDZero, most drones relied on an analog video system that ran at standard definition and 30 frames per second. But the HDZero system broke this norm. Although it technically runs at 720p at 60fps or 540p at 90fps, which isn't quite as high as the 1080p offered by DJI and Walksnail, the image quality is still significantly better than analog one, especially during high-speed maneuvers.

The Walksnail Avatar system is characterized by high image quality and compatibility with several FPV goggles. The way Walksnail works is more like DJI than HDZero. Like DJI, Walksnail uses two-way communication. Any lost or corrupted data packets are retransmitted to obtain the best possible image. This results in a higher image quality, but at the expense of a higher variable delay. The variable lag can be problematic for pilots who rely on real-time feedback for tight turns and obstacle avoidance.

Undoubtedly, cost remains a strong deciding factor. Although all HD systems are more expensive than their analog counterparts, durability and repair costs are important considerations.

It cannot be denied that digital FPV systems offer a significant improvement in image quality compared to analog ones.

When it comes to the need to use real-time image processing, of course, in any case, the video signal must be digitized, and therefore it is better to immediately use digital systems. The use of commercial digital systems for such tasks is not available because manufacturers do not disclose their transmission protocols. Accordingly, when solving the tasks of creating artificial intelligence for UAVs, it is necessary to look for a non-commercial digital alternative.

In addition to commercial digital video transmission systems for UAVs, there are many open-source software projects in the network that allow you to organize your own digital video communication system. The most popular digital video communication software projects include: OpenIPC, OpenHD, WFB-NG, Ruby FPV and .EZ-Wifibroadcast.

The paper proposes the development of its own digital video system for FPV drones, which will support the existing open-source software system and provide the possibility of further processing of the video stream, as well as the possibility of long-distance transmission with the possibility of relaying.

The scheme of the video transmission system can be conditionally shown by the following sequence: camera – gstreamer – RTP stream (UDP) – wfb_tx.

Wi-Fi Broadcast Extension is an open source digital FPV and telemetry system focused on one mission: reducing latency to ensure seamless real-time connections [2].

WFB-NG commands WiFi cards to go into monitoring mode. In this state, WiFi cards are free to send and receive any packets without the need for association or waiting for ACK packets.

Instead of serializing data into a continuous stream of bytes, WFB-NG maps the Real Time Transport Protocol (RTP) directly into IEEE80211 packets.

We chose the following equipment for the initial implementation of the digital video system. The IMX415+ MStar SSC328Q IP Camera Module was chosen as the camera for installation on the UAV. As a transmission module, a practical module based on the RTL8812AU chip was chosen primarily due to documentation, price, and the possibility of implementing amplification to the required power and, of course, data transmission speed, which is an important factor for building video systems. On the receiving side, the ICsee Xmeye XM Nvr Board was chosen to realize receiving and outputting the video signal to the display device. The AR9271 USB Wireless Network Card was chosen as the video signal receiver on the video receiving station side due to its compatibility with the Raspberry Pi and the selected video card.

The selected Wi-Fi modules require more power than they can get from the Raspberry Pi's USB port. The solution to such problems is to solder power from a BEC or other 5V power source to the Wi-Fi adapter(s).

In the project, we focused on the software implementation of digital communication with OpenIPC open-source code.

The selected components are not ideal for two reasons:

- there are extra components on the boards, which can be an obstacle when using small drones;
- the transmission module produces a power of only 1 W, which immediately puts it at a level below purchased digital systems.

Therefore, it was decided to develop our own hardware for the video capture module from the camera matrix and the on-board video stream transmission module.

The next stage was the development of a printed circuit board based on the scheme in the EasyEDA program. Based on the developed documentation, printed circuit boards of the module were manufactured at the Etal plant (Olexandria), and elements were soldered on an SMT machine in Kyiv (Figure 1).

As in the basic transmission module, the RTL8812AU microcircuit is used as a base, however, when developing the board's own design, the power of the transmission module was increased due to the use of amplifiers, and channel doubling was also done to ensure operation not only at the 2.4 GHz frequency, but also at the frequency 5.8 GHz, which will make it possible to switch to another in the absence of communication on one frequency band.

Based on the scheme, the printed circuit board was developed in EasyEDA and the device was ordered to be manufactured. The general scheme of the system is presented in Figure 2.

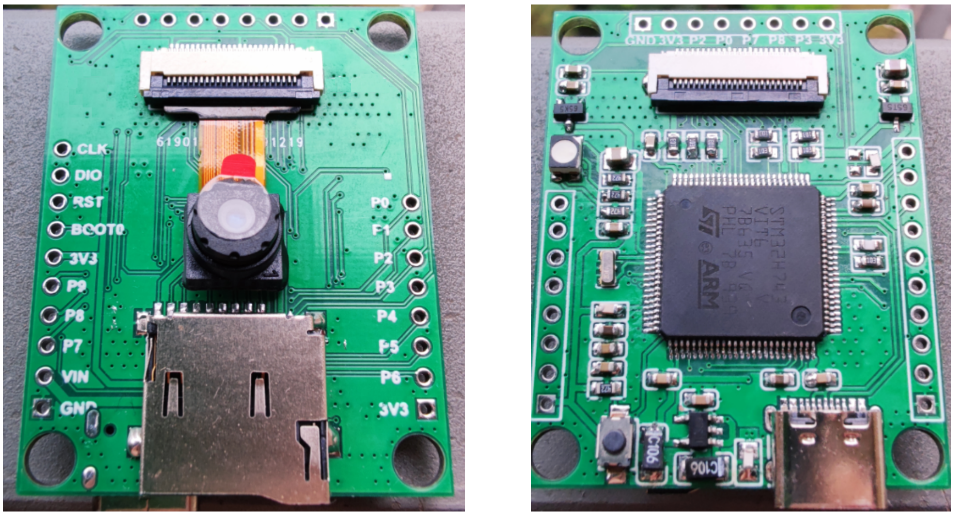

Figure 1 – Manufactured on-board video module:
a – top side; b – bottom side

Figure 2 – The general scheme of the system

After all settings were made, testing of the developed digital video stream transmission system was done.

At the first stage, the possibility of receiving a video stream from the developed video module was checked on a personal computer.

After confirming the functionality, housings for the blocks installed in the drone were designed and manufactured on a 3D printer to prevent their damage during operation.

For preliminary testing of the developed system, chrominance test signals were sent as a video stream.

After the operation was confirmed, the operation of the telemetry output from the flight controller was checked. The final stage of unmanned testing was to receive a full video stream from the telemetry via the radio channel.

Even before receiving the developed transmission modules with an enhanced signal level, the operation of the digital system in the drone was tested using purchased elements for the implementation of the on-board part. The testing showed the full operation of the developed system as part of the drone. Considering that a module with an output power of 2 W has been developed, it can be predicted that the operating range of the developed system will be at least 20 km in line of sight.

The developed digital FPV system has a lower cost compared to commercial systems, because of the openness of the code, it allows the robot to be relayed, and the more powerful transmission module allows to increase the distance of the operation.

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