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The Unmanned Robotic Complex For The Small Arms Fire Evaluation

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Abstract **— The article presents the developed unmanned robotic complex for evaluation of small arms fire. The complex is designed for effective training of soldiers and officers in shooting at close and long distances (20 ÷ 1500 m.). The operating principle of the system is briefly described and technical characteristics are given. The complex is equipped with a hydro meteorological station for correcting shooting in accordance with the ballistic characteristics of the projectile during shooting. The shaped target is made of polymer carbon plastic material and it has a long service life. The software for unmanned control of the robotic complex has been developed. It is shown that the proposed unmanned robotic system has significant advantages over foreign analogues.**

Keywords **— unmanned; robotic; evaluation; small arms; target; software**

I. INTRODUCTION

In recent years, the development of automated robotic systems for effective training on the accuracy of small arms fire has become more and more important [1,2]. There are products of a number of leading companies in the world engaged in the development and sale of such systems. Note that the products (systems) shown below are not simulators.

Smart shooting target allows to determine the accuracy and precision of fire quickly and with high reliability. Usually, a smart target consists of a target with acoustic sensors and a computer. The operation of the complex is based on the principle of acoustic accommodation. When the bullet flies at a supersonic speed, the shock wave affecting the target plane and acoustic sensors causes electrical signals to be generated in them, which allows to determine the point of impact on the target online and display this information on a computer monitor. After the fire is finished, its accuracy and grouping of shots are calculated automatically. All data is displayed in digital and graphical form on the PC monitor. The main disadvantages of the Smart target are as follows: 1) only one target can be controlled at a time, 2) it can be used only in closed places, thereby limiting the control range, 3) the use of a shock sound wave reduces the accuracy of determining the coordinates of the bullet hitting the target.

The PIAP MOBI TARGET shooting training system, created by Action Target Inc. in the USA [3], is well known. PIAP MOBI TARGET is a system for active shooting training. It is designed to train and improve the skills of employees of state security and defense services, as well as armed guards and sports shooters. PIAP MOBI TARGET consists of a mobile platform, an operator control panel (with a training interface) and a relay stationThe advantages of the system are its mobility, ability to act quickly and complete independence from the existing communications infrastructure.

PIAP MOBI TARGET can operate in close proximity to each other and near local obstacles on the shooting range. The robotic target moves up to 1200 m. This allows for sniper training, where shooters can fire at long distances. PIAP MOBI TARGET was designed with modularity in mind, allowing it to be configured according to individual customer requirements. Depending on the configuration, the mobile platforms can be equipped with paper target holders (basic version) or a 3D dummy lift equipped with a hit detection and parameterization system (advanced version). The weight of the PIAP MOBI TARGET system is 380 kg, the maximum radio control radius is 1200 m. The main disadvantages of this system are its large weight and insufficient efficiency in calculating the bullet hit points on the target.

Another product, Mantisx System, was developed by American specialists [4]. This system is designed to improve shooting skills from small arms (machine gun, pistol). The Mantisx System kit consists of a firearm, a special attachment to the weapon, a target, and a smartphone for reading and processing information about the bullet hitting the target. A special attachment is used to connect the smartphone to the target via

Bluetooth. The main disadvantage of the Mantisx system is its use at short distances, only 25 m.

This paper presents a developed and manufactured unmanned robotic complex for controlling shooting from small arms (machine gun, sniper rifle, and pistol). This complex can be controlled without an operator, automatically determining the coordinates of the bullets hitting the target and count the points of bullets hitting the target. Software for unmanned control of the robotic complex has been developed. The system is designed for effective training of soldiers and officers in shooting at close and long distances (20÷1500 m). The operating principle of the complex is briefly described; technical characteristics are given. It is shown that the proposed unmanned robotic complex has significant advantages over foreign analogues.

II. ROBOTİC FİRİNG SYSTEM

The unmanned robotic complex for evaluation of small arms fire is designed to teach skillful and effective handling of firearms. The shooting control system performs shooting and automatic assessment of the shooting task at various types of targets using automated software, technical equipment and a rotating camera. PTZ camera - Pan-tilt-zoom-camera - is a camera that supports remote control of direction and scaling. PTZ control is called robotic control system. It is equipped with pan, tilt and zoom control system. It is directed to specified objects under the control of internal controller.

This system is equipped with a hydro meteorological station for correcting shooting in accordance with the ballistic characteristics of the projectile during shooting. Fig. 1 shows the platform of the fire evaluation system together with the raised target. The figured target is made of carbon-filled plastic. The advantage of this material is that usually a paper target is glued to the chipboard target (chipboard is a wood material made by pressing wood chips), when it is hit, the turret breaks through it, and after some time a new target is required (the paper target is replaced for each shooter). However, the target made of polymer carbon fiber has a long service life, because this target is processed from time to time using a special technology.

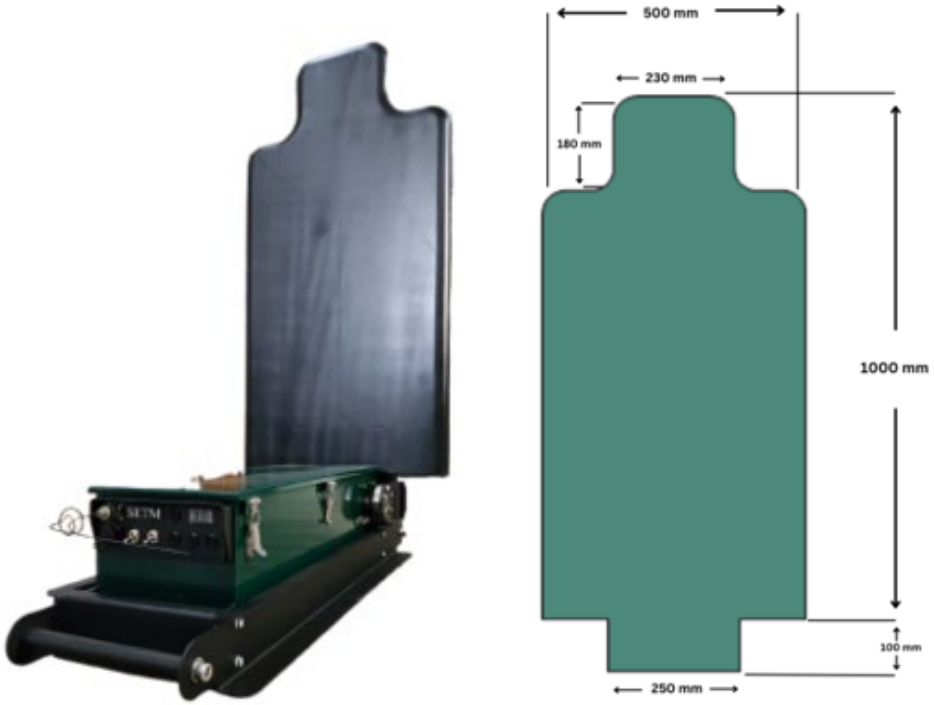

Figure 1. The platform of the fire evaluation system together with the raised target.

Advantages of the design capabilities of the unmanned robotic complex:
- a durable metal body that ensures long-term safe operation of the unmanned robotic complex, meets the conditions of transportation and manual transportation in landfill conditions;
- reliable, convenient and relatively quick fastening of figures with a special clamp;
- the presence of additional elements that ensure reliable fastening of the device to the ground and protection of the body from direct bullets;
- external battery in a separate protective case, allowing quick removal for charging, replacement or storage without the use of special tools;
- external power connector for uninterruptible power supply from a stationary network (without battery).;
- dust and moisture-proof projector for visible or infrared target illumination at night;
- highly accurate and sensitive adjustable inertial impact sensor for shot evaluation.

Table 1 shows the tactical and technical parameters of the unmanned robotic shooting assessment system.

TABLE I. TACTİCAL AND TECHNİCAL PARAMETERS.

N	Characteristics	Values
1.	Climatic conditions: - environment temperature - relative humidity, at ambient temperature of 10°C - wind speed, should not be more	 - 20ºC ÷ + 40°C 95% 15 m/sec
2.	Mechanical characteristics: - mass of the assembled product - overall dimensions - maximum power moment on the shaft - pitch or roll angle - lifting and lowering speed.	 57 kg 1000x310x220mm 110 Nm 90±3º < 3 sec
3.	Energy characteristics: - nominal supply voltage - maximum power consumption - battery capacity - number of complete ascent-descent cycles (with a fully charged battery, at the permitted operating temperature)	 10,8 V ÷ 13,8 V 40 W 50 Ah 6000 times
4.	Lighting system characteristics: - target figure lighting mode (infrared/white): - lighting frequency	 continuously or at a given frequency; 1 ÷ 5 Hz
5.	Radio channel characteristics: - number of targets used at the same time - control distance - radio frequency - radio wave power (depending on distance)	 10 units 20 ÷ 1500 m 140÷170 MHz, 400÷470 MHz 0,1 ÷ 1 W

The advantages of the shot control system are:
- possibility of use in various terrain;
- automatic evaluation during shooting;
- possibility of night shooting;
- the number of targets connected to the control panel is 2-10 units, connection time is 5 minutes;
- the ability to use a battery regardless of the electrical network;
- a protocol for controlling target lifts (fixed, non-fixed);
- control via RS-485 or radio channel: RS-485 is a two-wire differential transmission standard that provides high-speed data transmission over long distances; the 485 interface typically uses DB9 or DB25 connectors, as well as special connectors;
- it is possible to increase the control distance (upon request);
- simultaneous shooting in pairs, squads, groups;
- constant control of the shooting area by the camera.

Figure 2 shows a simplified block diagram of the unmanned robotic complex control software for evaluation shooting from small arms.

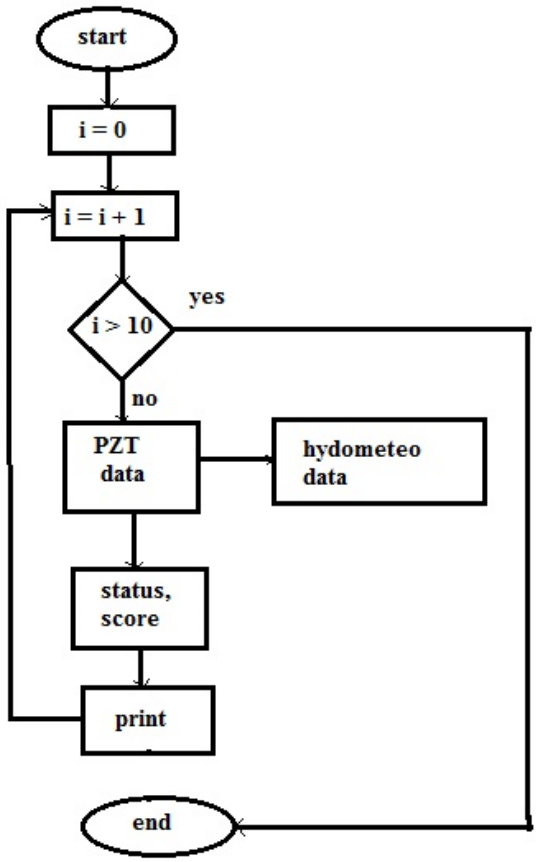

Figure 2. A software of the unmanned robotic complex for controlling shooting from small arms.

The control begins with the Start command, when the complex's electrical power is turned on and all its functional modes are checked. Then all data in the control memory of the complex is reset to zero. At the next step, the 1st (i = 1) target is requested and it is checked whether the number of this target is greater than 10 or not (i > 10). If the target number is greater than 10, then the evaluation process ends (go to the End block). If the target number is less than 10 (i < 10), then all PZT block data is requested (target number, type of target: standing or chest figure), coordinates of bullet impact points on the target, distance to the target) and hydro meteorological data.

In the next control block, the status (state of the target: it is raised or lowered) of the shooting results is determined, and the shooting is evaluated (scoring). After this, the shooting results are recorded in the memory of the control unit and can be printed at the request of the customer.

After this, the analysis moves on to the next target and everything is repeated from the beginning. The maximum number of targets that the control system can interrogate is 10.

In addition, from the comparison with foreign analogues it is clear that the system we offer has significant advantages.

CONCLUSION

Thus, the paper presents an unmanned robotic complex designed and manufactured for the assessment of fire from small arms (machine gun, sniper rifle, pistol). This complex can be controlled without an operator, the coordinates of the bullets hitting the target can be determined automatically, thanks to which it is possible to assess the accuracy of the shot and calculate the shooter's score. The software for unmanned control of the robotic complex has been developed. The system is designed for effective training of soldiers and officers in shooting at close and long distances (20 ÷ 1500 m). The target is made of polymer carbon fiber and has a long service life. The proposed unmanned robotic complex has significant advantages over foreign analogues.

REFERENCES

[1] A. Bayramov, S. Suleymanov, F. Abdullaev, The Robotic Control System of UAV Based on Artificial Intelligence Technologies. In: Ronzhin, A., Savage, J., Meshcheryakov, R. (eds). Interactive Collaborative Robotics. ICR 2024. Lecture Notes in Computer Science, 2024, vol. 14898. pp. 357-367. Springer, Cham.

[2] A. Bayramov, S. Suleymanov, Remote Control Robotic System for the Perimeter Security. In: Ronzhin, A., Sadigov, A., Meshcheryakov, R. (eds) Interactive Collaborative Robotics. ICR 2023. Lecture Notes in Artificial Intelligence, 2023, vol. 14214. Springer, Cham. Chapter 16. pp. 175–184.

[3] PIAP mobi target robotic shooting training system. https://www.antiterrorism.eu/portfolio-posts/robotic-shooting-training-system/ 22.August.2024.

[4] Mantis firearms training system. https://mantisx.com/pages/how-it-works-1 06.September.2024.