Synthesis Control System Physiological State of a Soldier on the Battlefield

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Abstract. The problem of synthesis of the remote control system of the physiological state of the warrior at the forefront in the conditions of close combat on the basis of modern systems of information technologies is considered. The basic principles of construction of the control system and its integration into the equipment of the warrior are considered, which will allow to react promptly to any changes in its condition.

Keywords: IoT, Autonomous Serviceman Control System, Communication System

1 Introduction

Ukraine is in a state of war today, as a result of the nature of the fighting, as well as the growth of their pace, scale and tension, the requirements for control over the vitality and combat capability of military personnel in the modern conditions of combat operations are increasing. According to an analysis of the consequences of the fighting in which the wounded died, 50% of them could have survived had they been given first aid within the first six hours after the damage had been sustained. Moreover, 15% of the victims need resuscitation during the first 15-30 minutes after the injury, otherwise they die from bleeding, obstruction of the airways, severe brain damage [1-9]. The conditions described above lead to hypovolemia, asphyxia, and shock. As for the shock conditions in the victims, they are caused by the following reasons: traumatic shock, hypovolemia; cryogenic shock, complete impaired blood flow due to mechanical interference, impaired blood distribution in the body, etc.

Based on the above, it becomes necessary to use a system of constant monitoring of the physiological state of the military personnel and to receive a signal at the time of deviation from the specified intervals of the norm, regardless of the geographical location of the affected within the coverage of the wireless network. Based on the data obtained, make decisions on the remote introduction of certain drugs, as well as the

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urgency of the evacuation of the injured serviceman [10-16]. The development of modern diagnostic methods together with the rapid development of information and communication technologies have led to the creation of completely new methods of providing medical care, where information technologies play an important role.

2 State of art

Today, there are systems for monitoring the physiological status of a soldier on the battlefield. Warfighter Physiological Status Monitoring, for example, is a pretty good, high-precision system that has been tested not only in the laboratory but also in combat [23]. The advantage of the system is its performance, as well as the accuracy of the data obtained. On the basis of which conclusions can be drawn about the further treatment of the soldier. However, the system is not without drawbacks [20-25], for example, data transmission is done via radio frequencies, which already limits the range of the system. Also, the system is not capable of operating as one particle of a large system [10-19].

3 The system architecture

The outfitting of military personnel must meet the modern requirements of tactics based on new approaches to the execution of combat and special missions. One of the priority areas of research in the creation of combat equipment is medical control of the functional status of servicemen and assessment of the location of the victims due to injury, contusion, exposure to chemicals, poisonous gases on the serviceman. The physiological remote control system is a portable system of medical control of a serviceman, which automatically provides the processing of signals from medical sensors, determining the location of the navigation system and the transfer of all information to the mobile hospital.

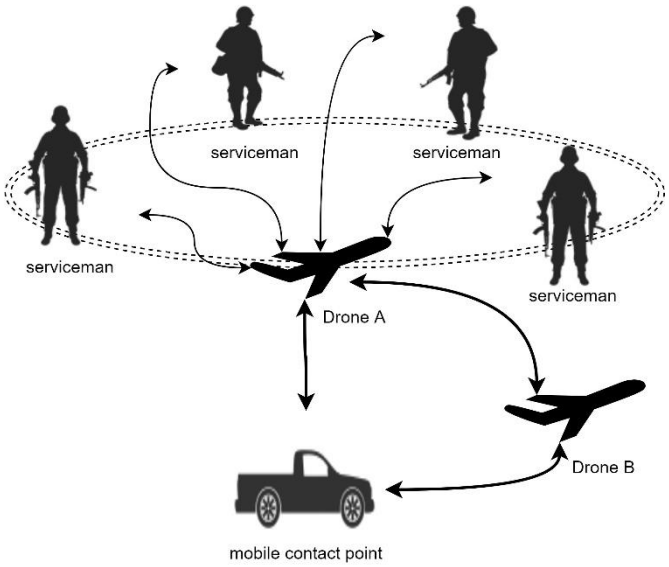

Fig. 1. Standard system of communication between military personnel and the consulting and diagnostic center

Where decisions will be made regarding emergency care, evacuation of the wounded from the battlefield, and remote administration of medications from a backbone or wrist first aid kit to stabilize the affected condition prior to the arrival of the emergency room. Because, the battlefield is a place where non-standard injuries, injuries, injuries, etc. occur. there is a need not only to monitor the status of each particular serviceman, but also to keep a video stream, to consult him in a particular case. Stream video is widespread in the use of special units around the globe, as only video can ascertain the legitimacy and legality of detainees. The miniature camera mounts on the helmet and practically does not change its weight, since the complex weighs from 75 to 150 grams.

Communication between mobile consulting and diagnostic center and provide military drones (Fig. 1), which is continuously moving over the battlefield and describe the eccentric circle. The transmitter of each serviceman keeps in touch through a closed channel in real time with a drone, which is currently in his field of view, through a wireless network. The drone in turn transmits information to the next drone through more powerful transmitters, thus forming a network with closed channels. The nearest drone I pass the final information to the consulting and diagnostic center. The trajectories of drone's overlap and cover the entire battlefield. However, a variety of unforeseen circumstances arise, such as a drone being knocked down by an opponent, and at the moment there is no drone that could take the information and pass it to the final destination.

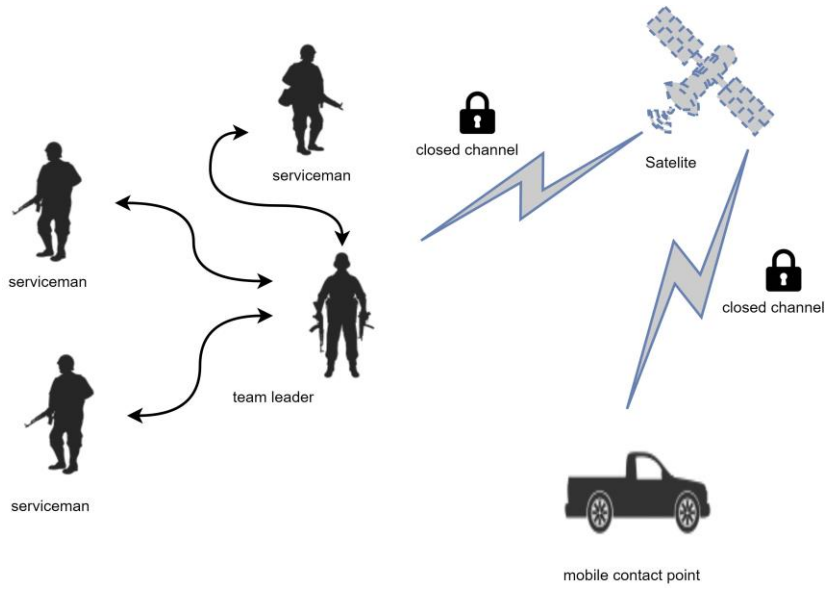

Fig. 2. Secondary system of communication between servicemen and the consulting and diagnostic center

So spare communication option is satellite, which switches if necessary, this function has one head unit (Fig. 2) and after it is restored relationship with each individual. This option is spare and short-lived until another drone is blown up, as this option is more reliable, less expensive and less energy consuming.

The medical system includes a variety of medical equipment, based on sensors to control the physiological status of the serviceman and monitor the condition of the wounded under the control of the ESP-32 microcontroller. The other half of the system is housed in a mobile consulting and diagnostic center that combines communication with each serviceman, as well as controls the transportation and evacuation of the wounded.

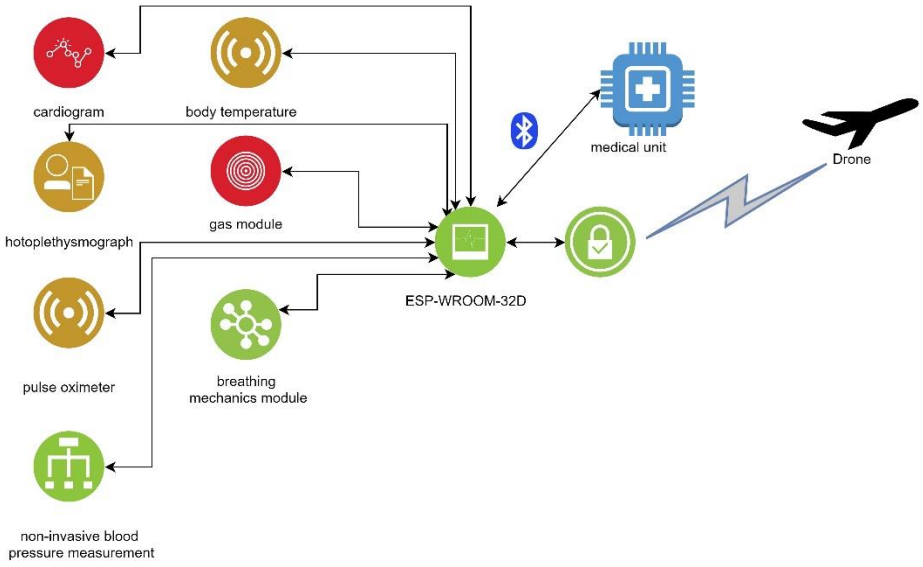

Fig. 3. Schematic diagram of the main block of the system of control of the physiological state of the serviceman

Returning to the system of control of the physiological state of military personnel, it can be said that it will be stolen from several blocks (Fig. 4). The first is the main unit, which will be placed behind the fighter's back, under the vest, the main function of such a unit is to collect information from sensors and to transmit it in real time via a drone to a mobile consulting and diagnostic center. The unit will be powered by high capacity lithium-ion batteries. These batteries are recharged from the 220V network and from the Peltier thermoelectric generators, which provide current in a circle from the temperature difference on different sides of the element. The communication between the sensors and the ESP-32 is made by contact method, using a line made of soft copper wire, which is sewn into the mold.

The second important part of the system is the medical unit, which is, in its essence, a modernized first aid kit that attaches to the hips and packs certain medicines. In the event of a critical situation and the serviceman is unable to self-administer certain drugs as a result of the shock example, the operator makes a decision and introduces the drug with the help of a remote-controlled injector. Thus, warns, for example, loss of consciousness from pain shock. The input system is based on a cascade of servo drives that are energy efficient. In terms of proper operation, and consequently safety, since the system must operate at a certain point in time, the system has autonomous power supply. Communication between medical and head units is made using bluetooth 5.0 technology, which has a fairly high stability and energy efficiency.

There are several basic tasks that the system of monitoring the physiological condition of a serviceman should perform, namely:

1. real-time monitoring of the user's current state, fatigue and performance;

2. quantitative and qualitative assessment of congestion, endangering the health of the user of the system;

3. the complexity of assessing the condition of vital organs and systems;

4. multi-parameter control;

5. continuity of control;

6. high accuracy of measurement of parameters;

7. convenience and ease of use of sensors;

8. dialogical configuration of the complex, taking into account individual features of the system user;

9. retrospective analysis - storage and reproduction of data.

The use of the complex should allow to carry out:

1. without load integral evaluation of functional state;
2. load estimation;
3. control of recovery measures;
4. control of the effect of medication.

On the basis of a long and continuous analysis of a large amount of data characterizing the state of physiological systems of the body, it is required to provide not only operative diagnostics, but also the prediction of the patient's condition. To determine therapeutic tactics, it is necessary to clearly formulate a diagnosis, consisting of three characteristics:

1. Morphological (severity, character, localization).
2. Life-threatening effects of injury (asphyxia, external, internal bleeding, brain compression, pneumothorax, limb ischemia, and so on).
3. Clinical characteristics of the severity of the condition of the affected (traumatic shock, acute respiratory failure, traumatic coma, etc.).

4 Assessment of the state of the victim

The multiplicity of injuries of different areas of the human body, their different severity, the need to determine the order of medical measures on the degree of their emergency, the constant shortage of time for decision making require the ranking of severity of damage. This is especially necessary for sorting at the mass flow of casualties in combat. In addition, an objective assessment of the severity of the condition allows you to identify homogeneous in severity of the group of patients, to evaluate the effectiveness of resuscitation in the dynamics. These circumstances explain the desire to create a scale that allows you to reflect the severity of trauma in quantitative indicators that can be summarized in tables and mathematical formulas. From a practical standpoint, the severity of the damage and the severity of the condition with these injuries are ambiguous quantities. Often the severity of the condition of the victim is inadequate to the functional damage caused to the body in trauma. Based on this, indices, scales and techniques have been proposed in recent years to evaluate the severity of injuries based on either anatomical or functional features or a combination thereof. Dynamic evaluation on the integrated scales and prognostic indices allows to objectively evaluate the effectiveness of vital care intensive care and to make timely

changes to the treatment algorithm. The severity of injury determines the morphological damage suffered by the body as a result of trauma and is characterized by the sum of anatomical disorders that have occurred. This is a relatively stable indicator, the value of which is determined as a result of life-long diagnostic measures. The severity index reflects the body's response to the injury within a specific time frame. This indicator is dynamic and is determined by many factors: the age of the victim, his compensatory capacity, the duration and quality of assistance, etc. So far, a large number of different injury severity scales have been created, but in practice they use only the simplest and most informative ones created to NATO standards. In all scales, the leading place belongs to the expert evaluation, so they are not devoid of elements of subjectivism. Experts' assessment is unanimous in determining absolutely fatal injuries, such as decapitation, complete transverse aortic rupture, liver or pelvis fractures, and the like. The margin of error in compiling a list of minor injuries is relatively small. But in determining the severity of critical and life-threatening injuries, there are many discrepancies and errors, especially in cases where the damage is described in general, in an unspecified form. All scales used have common disadvantages: poor discriminatory outcome for an individual patient with a relatively accurate prediction of the probability of death for a group of patients, low sensitivity of the scales at sufficiently high specificity, which allows more or less accurately predict the probability of death, but does not allow reliably identify surviving patients.

4.1 Monitoring of actual physical parameters

The construction of tools for diagnostics of the state of the organism is based on the registration of physiological data and their subsequent evaluation in order to determine the indicators characterizing the work of the most important systems of the body. Methods for the study of physiological processes should ensure the continuous recording of biological signals in real time in combination with the high diagnostic value of the indicators obtained from the processing of signals from the sensors. The most important of these are the methods of monitoring the indicators of the cardiovascular system, central nervous system, function of external respiration. A large number of methods can be used to detect diseases in screening mode. Physiological parameters can be defined either directly as measured physical quantities, such as temperature, pressure, bioelectric potentials, or as values that characterize the interaction of the body's physiological processes with physical fields, such as the amount of attenuation of optical radiation that has passed through the tissues under study, ultrasound, electromagnetic waves.

Modern monitors have moved from individuals who are stored to save changes that contain integral indicators that are stable. The integral metric may be open to making possible the use of a generalized criterion based on the degree to which private sources deviate from the "ideal" alternative. As a measure of the generalized criterion remains, the degree of possibility of values of physical functions can be used at a given time, limiting their dynamic norms. The selection of physical parameters and employees for system monitoring has opened its information data on the assessment of physical physical condition and its response to various factors. Monitoring

standards are currently proposed that adhere to the required methods and use of other individuals, health care, that is trusted by the legislators of NATO members.

5 Results

Since communication between the military personnel and the consulting and diagnostic center takes place in real time, it is important to have the speed of transmitting the measured information from the sensors. After all, it depends on the priority of providing medical care, the priority of departure of the operational brigade, and as a consequence, the life of a serviceman.

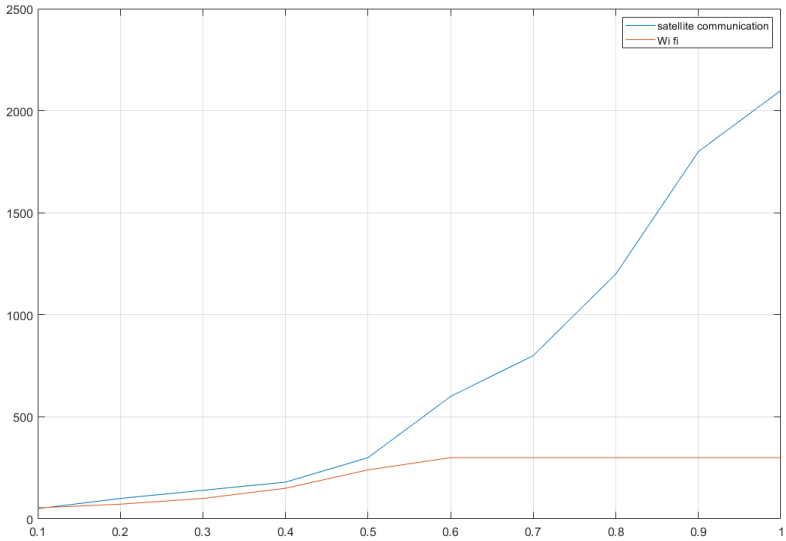

Fig. 4. Relation of data rate over satellite and wifi to distance in relative units

The performance of the data transmission from sensors located on the serviceman to the remote-based system was investigated. As can be seen from the dependence, the speed of both transmission channels is the same to a certain limit in relation to the distance, which is sufficient for communication between the serviceman and the consulting and diagnostic center.

6 Conclusions

The professional activity of military personnel is characterized by increased workloads on their functional state of health and, as a result, increased attention on the part of the medical service. Establishing and implementing a system of remote medical control of the combatant's military capability based on modern information technologies will allow to reduce personnel losses on the battlefield from injuries received by optimizing the process of finding and evacuating the wounded and improving the

quality of assistance at the frontier of medical evacuation. The development of recording and processing methods for biological signals, as well as the widespread use of microprocessor technology, has led to the integration of individual measurement and control devices for physiological parameters into multifunctional monitoring systems that allow a comprehensive assessment of the patient's condition. Improvement of measuring equipment and methods of processing physiological information opens new opportunities in the diagnosis of the condition of the body.

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