TELEMETRIC SYSTEM FOR MONITORING THE PARAMETERS OF AN EXPERIMENTAL STAND FOR TRACKING THE DAMAGING EFFECTS OF PENETRATING WOUNDS

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Abstract. *At this time, there are many threats that lead to penetrating gunshot wounds that need to be promptly and effectively diagnosed, and that require a great deal of effort in the treatment process to preserve the patient's life and health. The problem is complicated by the fact that the formation of the wound channel depends on a large number of influencing factors: the type of bullet, speed, torque and other factors, which cannot be determined during the initial examination and diagnosis of patients. There are many methods of analyzing the behavior of a bullet when passing through a patient's body for the formation of general contaminations and the study of this phenomenon: including the use of ballistic stands-simulators of a biological object. The authors considered the possibility of providing such ballistic stands with a high-speed telemetric system for controlling the parameters of the experimental stand for studying the striking effect of penetrating wounds.*

Keywords: *disaster surgery, penetrating wound, ballistic stand, telemetric parameter control system.*

Introduction

During explosions or shots, some objects acquire a large kinetic energy and unfortunately can injure people, causing penetrating wounds [1]. These wounds have a thermal, mechanical and chemical effect on the human body. In this case, the penetrating object creates a large cavity that often exceeds the size of the object itself.

In addition, local damage may occur around the wound channel, which during the healing process causes disturbances in the human body. This situation leads to diagnostic difficulties in determining effective surgical and therapeutic measures [2]. Therefore, for the successful treatment of wounds, it is important to have a deep understanding of the physical processes associated with the intervention of fast elements in the human body [3].

This problem is aggravated by the lack of critical medico-biological information, which would allow to quickly and effectively classify the patient's condition, determine the features and severity of the clinical case, as well as to manage and monitor his health on the basis of objective medico-biological indicators (Fig. 1).

Therefore, the search for new effective methods of diagnosis and monitoring of the condition of patients with penetrating wounds caused by highly kinetic foreign bodies is currently an extremely relevant area of scientific medical research and is of great practical importance in civil and military emergency medicine.

One of the methods of studying the impact of penetrating objects on the human body is the use of ballistic stands, which provide information on the formation of wound channels, using non-biological materials as samples.

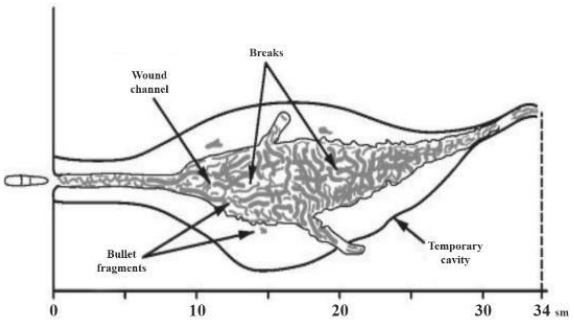

Figure 1. Impact effect of projectile

The telemetry system considered in this paper is an information and measurement system (IMS) that collects and performs primary processing of signals received from sensors during experiments on the penetration of foreign bodies on a human body simulator, and transmits this information to a personal computer through a wireless communication channel.

The structure and principle of construction of the control system of the parameters of the experimental stand for the study of the striking effect of penetrating wounds.

It is important to study the dynamics of the formation of the wound cavity and determine the physical factors influencing its formation. For this purpose, a ballistic stand simulator of a biological object is primarily used.

The authors considered the possibility of providing such ballistic stands with a high-speed telemetric system for controlling the parameters of the experimental stand for studying the striking effect of penetrating wounds.

To consider this issue, we will consider the structure of the experimental ballistic stand and options for implementing the parameter control system for it.

The experimental ballistic stand will consist of the following parts:

- The object is a dense block of ballistic clay capable of accommodating a set of sensors of various types, selected according to the parameters of the movement of penetrating elements, taking into account the properties of the material;
- The information and measurement system (IMS) is a distributed system of collection and primary processing of signals coming from sensors.

IMS is built on interchangeable sensor nodes with controllers, information input/output modules and sensors distributed in space. The characteristic features of this type of the information and measurement system are the presence of decentralized data processing and distributed input/output systems, resistance to failures and a standardized, unified structure of the database [4].

In order to organize the transmission of data from the sensors to the information gathering node (IGN) (Fig. 2) and to the personal computer, it is necessary to organize a communication channel and ensure reliable power.

The information gathering nodes (IGN) of the telemetry system will have a wired connection only directly with the sensors, and data transfer from the microcontroller (MC) to a personal computer will be carried out wirelessly. Such a solution will ensure the reliability and stability of the system even if some system elements are damaged during operation.

As a control element for the IMS node (IGN), we will use a MC that will be capable of wireless data transmission. Then the node (IGN) will consist of three parts: a microcontroller with an attached Wi-Fi module, a sensor connected to it, and a power supply circuit. That is, in the system, each sensor will have its own microcontroller.

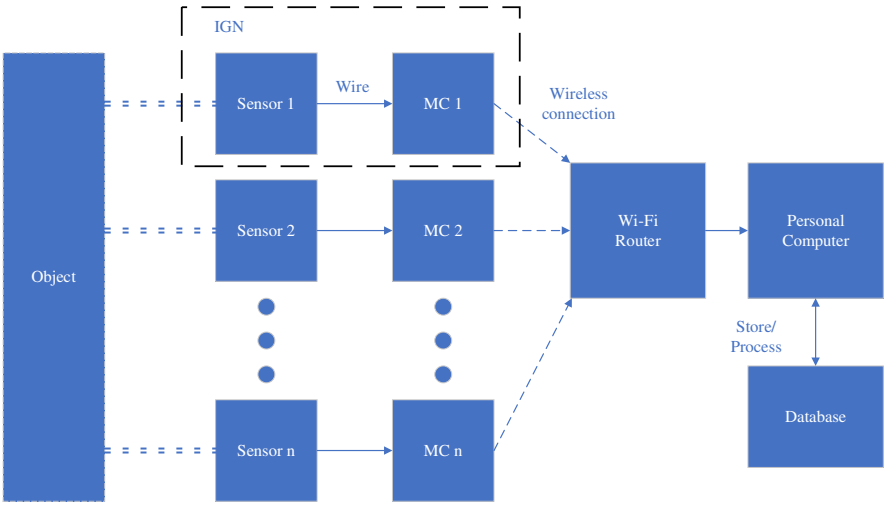

Figure 2. Structure of the information and measurement system

To obtain data from the object during the experiment, we will take an accelerometer as a pulse wave propagation sensor, and as a temperature sensor, we will take an analog thermistor, which we will connect to a high-speed ADC. We will connect both sensors to the MC through the high-speed SPI bus. This will ensure the highest speed of reading data from sensors (Fig. 3, Fig. 4).

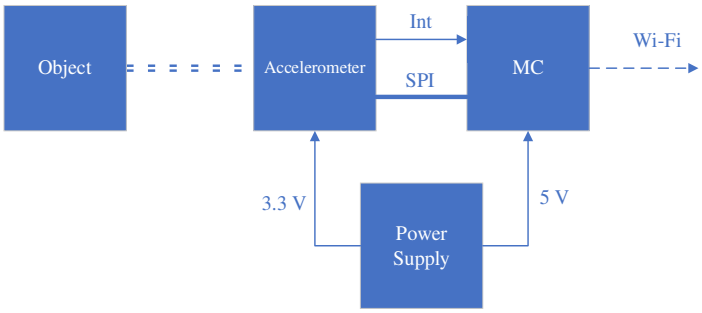

Figure 3. Structural diagram of the system node with an accelerometer

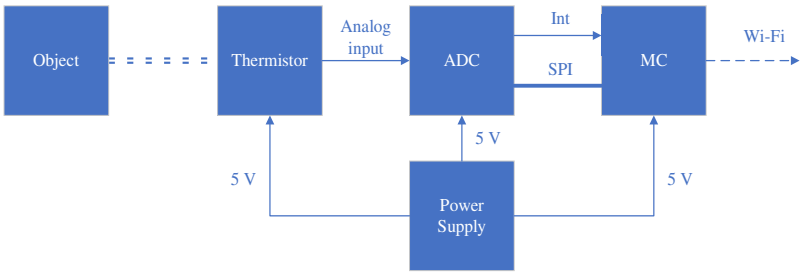

Figure 4. Structural diagram of a system node with a thermistor

The sensors must be physically connected to the object (a simulator of the human body made of ballistic clay) and set to work continuously with the accumulation of calculated values in the internal memory.

The software for IGN should work in asynchronous mode: when a part of the internal buffer is filled, a signal is triggered and the microcontroller reads data from the sensor's memory into the MC's RAM in batches via the SPI bus for each channel. The obtained values are in the form of a

single packet, which after a certain time, or after the experiment is completed, is sent to a personal computer using Wi-Fi.

IMS is intended for the study of short-term processes, therefore, it should be a node of system synchronization. With further research, it will allow to compare data from sensors of different nodes over time, to obtain the state and changes in the process in general.

For this purpose, it is proposed to add the so-called "Time Source" to the system, which will be used to synchronize the nodes of our IMS. It can be, for example, a local SNTP (Simple Network Time Protocol) server, which before the start of the experiment will send a packet with a countdown to the system t_0 .

Next, during the experiment, a time stamp t will be added to each data packet, which is determined by the formula: $t = t_0 + t_1$, where t_1 – local time elapsed since the start of the experiment. It will be counted by the internal RTC (Real Time Counter) clock of the microcontroller.

One of the tasks of the IMS is to measure the speed of the penetrating element using a chronograph with the possibility of recording the measured speed value. It is located directly in front of the ballistic clay (Object).

Among other features of the system, we would like to highlight the automatic start of testing. It is proposed to add a power switching scheme of the electric mass accelerator (EMA). It will act as a cannon in the experiment. The accelerator consists of a solenoid and a dielectric barrel into which the projectile is inserted.

When an electric current is applied to the coils of the solenoid, a magnetic field is created, which accelerates the projectile. That is, the energy of the field is transformed into the kinetic energy of the projectile, and it "takes off" from the barrel at high speed in the direction of the ballistic clay object, simulating a shot from a firearm into a human body.

Such a solution will facilitate and fully automate the process of conducting the experiment, and the human operator will only have to press the appropriate start button, as well as fix the time of the start of the experiment in the same frame of reference as the data from other sensors of the system. The scheme of the experimental stand and the information and measurement system, taking into account the specified changes, is shown in Fig. 5.

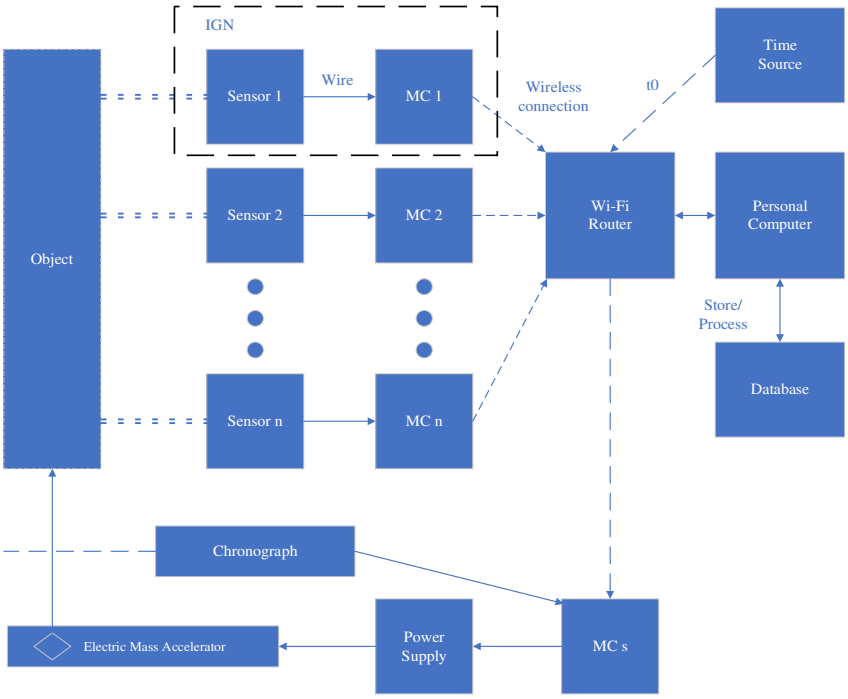

Figure 5. Structural diagram of the stand and IMS with a synchronization system

The described experimental stand with a telemetric parameter control system integrated into it, including an object (simulator) and an IMS, should ensure the fixation of physical parameters, such as acceleration and pressure during the penetration of the element into the human body simulator. The synchronized system will allow comparison and integration of data from different sensors, increasing the reliability and accuracy of measurements.

Conclusions

The authors considered the possibility of increasing the effectiveness of the study of the dynamic influence of physical factors of penetrating gunshot wounds on the formation of a wound channel in the patient's body by equipping a ballistic simulator with a telemetric control system for these parameters. At the same time, the general principles and features of such a system were determined, and practical proposals were made regarding its structure and organization. The work carried out is an important step in the practice of increasing the efficiency of diagnosis and treatment of patients with gunshot wounds, and will be used for further scientific research.

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