Experimental facility control system for optical studies in the frame of problem solving of brain hematoma diagnostics

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Abstract. The article describes a system to control a unit moving to find the dependence of the photodetectors signals from the distance to the hematoma. It considers existing devices that operate in accordance with the principle of near infrared spectroscopy and reveals their limitations the illuminations of which are our key objective. The limitations of the designed unit are described and possible ways of upgrading the system are outlined.

1. Introduction

Identification of intracranial hematoma is extremely important in traumatic brain injury. For now the most accurate methods for detecting such injuries are computed tomography and magnetic resonance imaging, however it is almost impossible to perform the tomographical scanning immediately after the injury. Therefore, the problem of creating a device that could quickly identify the intracranial hematomas is important. Possible solution of this problem is to use a diagnostic spectroscopy in the optical wavelength range. This method is based on the fact that the substance has characteristic absorption spectra of molecules, and the intensity of the absorption is specified by the content of the absorbing component within the irradiated object. The spectral region used in this work is not harmful both for an operator and a patient. With proper technical support is possible to investigate the organs and tissues of animals and humans, without violating their integrity and without causing any damage to the body [1].

2. Problem definition

InfraScan company has developed a device Infrascanner [2, 3]. It is a portable detector of intracranial hematomas operating in its near infrared range (808 nm). According to the published experimental studies performed on models of intracranial hemorrhage, clinical trials have shown a high diagnostic sensitivity of the device. This scanner allows you to detect the presence of hematomas with 91 % probability (in the case when hematoma is not deeper than 2.5 cm from the brain surface and is greater than 3.5 cm) [4, 5].

However, this device does not allow to receive data on hematoma such as its size, density, exact location and etc. that are of great diagnostic value for further resuscitation and rehabilitation medical treatment. Since the diagnostics is performed by comparing the optical properties of symmetric sections on the head surface in exact locations, there is a high probability of missing small or deeplying hematomas outside of these zones. Therefore, it is necessary to improve the method and upgrade the device for getting better medical and technical characteristics.

We design a model of the device that allows to carry out a laboratory research which will help to improve optical detection diagnosis of hematomas. For this purpose we are facing many challenges,

such as, design and engineering implementation of the optical part of the device, processing of the analog signal received from the photodetectors, digital processing and visualization of information read from the device.

3. Experimental unit

Construction of the laboratory model of the device is shown in Fig.1 [6]. Measuring optical part of the device consists of a carcass and movable fastenings (4). The optical block (2) is fixed on a carcass using a movable fastening. This optical unit is placed above the phantom of human head (3) and consists of a radiation source and receivers. A movable fastening (4) is used to fix a model object (5) that imitates the hematoma. The optical unit and a fastening for "hematoma" are fixed to the carcass using flexible and sliding joints, which allows us to move them both vertically and horizontally with respect to the phantom of the head.
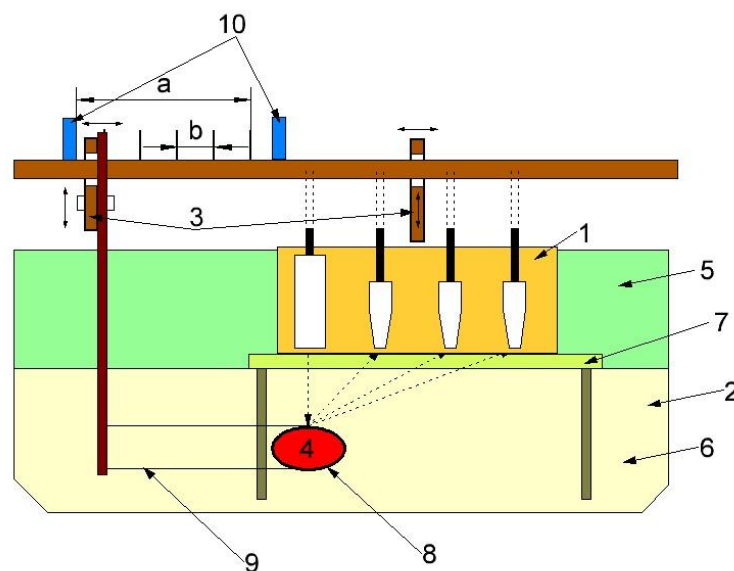

Figure 1. Construction of the laboratory model of the device. 1 – optical block; 2 – phantom of head; 3 – movable fastening; 4 – hematoma; 5 – volume; 6 – liquid imitating brain tissue; 7 – fluoroplastic plate; 8 – silicone transparent bag; 9 – wire grid; 10 – switches.

The phantom of the head consists of a container (6) filled with a dispersed viscous fluid (7) simulating the brain tissue. Above the liquid surface a fluoroplastic plate (8), which simulates the cranial bone, is placed. The hematoma is modulated by the human blood placed in a transparent small bag (9) fixed on a wire grid (10) of the movable fastening (4) and is set into the liquid under the fluoroplastic plate.

Varying the position of 'hematoma' relative to the optical measuring unit we can determine how its movement change the data received from photodetectors and whether on the basis of these data to determine the size of the hematoma and its exact location. For this purpose it is necessary to develop a device that would move the hematoma by a predetermined distance a with a given step b. In those moments when the unit reaches a given step b the values must be read from the photodetectors. Thus we get the dependence of the photodetectors signal from the distance to the hematoma.

The stepper motor is used to move the fastening with hematoma. Switches (11) limit the distance that the stepper motor can move the optical part of the device. The switch located to the left corresponds to the starting point that begins data reading. The switch to the right corresponds to the maximum distance at which hematoma can move.

Block diagram of the device for controlling the stepper motor is shown in Fig. 2. A program that controls the data acquisition device NI USB-6009 runs on a personal computer. This device has 12 channels of digital input / output, these pins are used for transmitting control signals to the microcontroller, and for transmitting data - values of "distance a» and «step b». The microcontroller STM8S003K3 sends control signals to the stepper motor (SM) TM100 and receives signals from the switches. Fig. 3. shows the algorithm of the microcontroller program. Chip ULN2003 is used as a SM-driver for coordination of voltage levels to control the stepper motor.
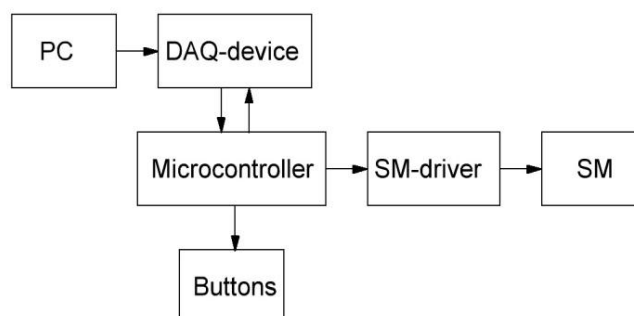

Figure 2. Block diagram of the device. PC – personal computer, DAQ-device - data acquisition device, Microcontroller- microcontroller STM8S003K3, SM – stepper motor, SM-driver – driver for stepper motor, Buttons – switches are limit the distance that the stepper motor can move.

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The program on a PC for measuring the position of the hematoma depending on the value from photodetectors is implemented in software development environment LabView. The program works as follows. First, the user enters the depth of the hematoma, then enters the distance – a that the hematoma must pass, and enters the value of step – b. After clicking the "Run" button the measurement starts. First values from the photodetectors are read. Then a control signal is sent to the microcontroller, and the unit begins to move at the given step. At this time, a microcontroller puts a prohibition to read data from the photodetectors. Once the hematoma has moved a predetermined step, the microcontroller sends the enable signal to read data from the optical part of the device. Now the data of the distance b is read. Then the device goes another step, data of a distance 2·b is read. And this process occurs until the unit passes the distance a specified by the user. Thus, after completion of reading data, we get the dependence of the photodetectors output signals from the distance to the hematoma.

4. Conclusion
As a result of this work a stepper motor has been implemented to automate data reading from the optical part of the device. The programs have been debugged. Further the experiments to determine hematoma location will be carried out using the device.

Further it is planned to develop our own software for the visualization of information read from the device. To get more high-speed data retrieval and to reduce the mass-dimensional parameters of the device it is planned to substitute the data acquisition device NI USB-6009 for analog-to-digital converter chip.
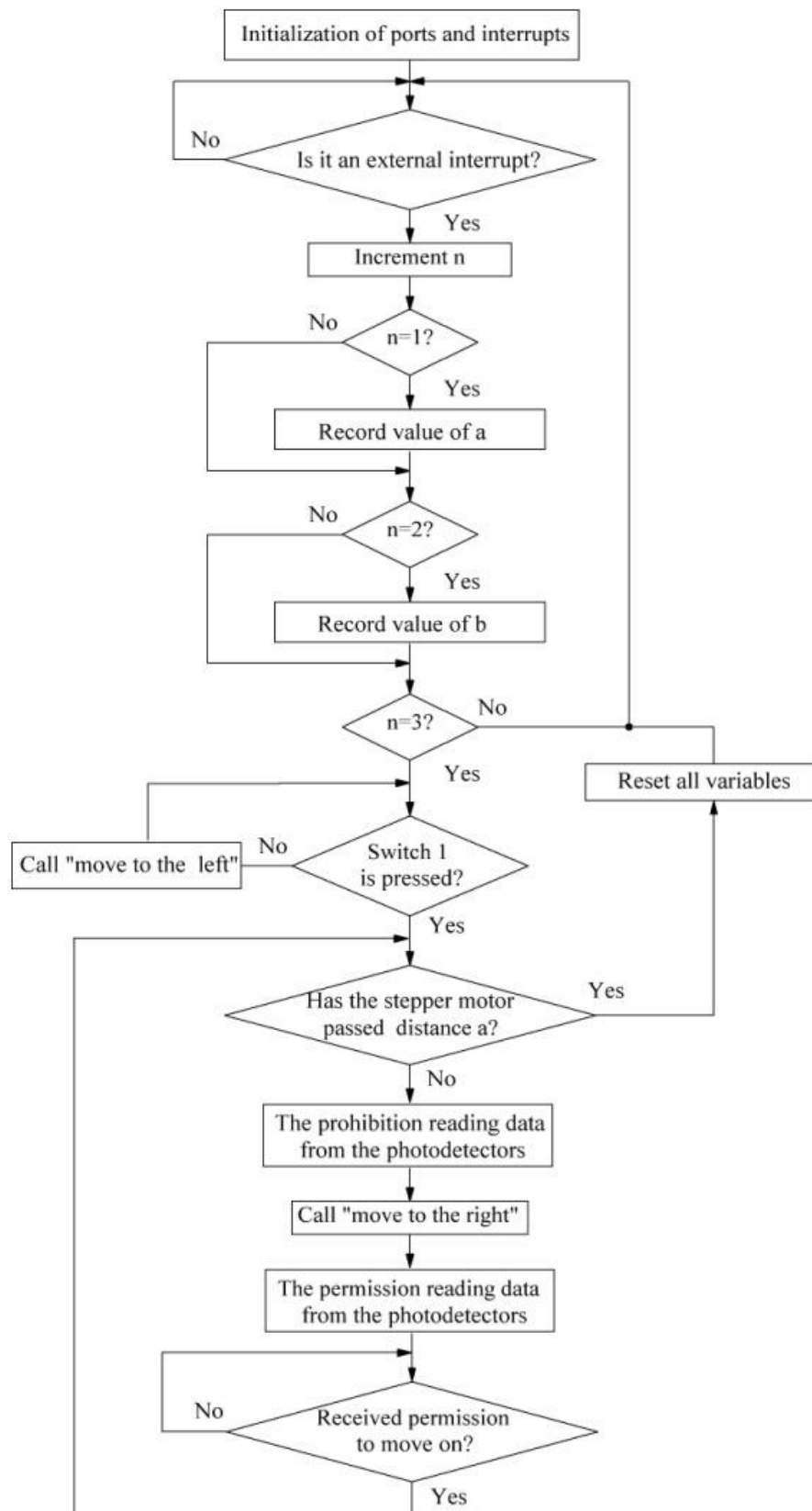
Figure 3. Flow chart of program algorithm embedded into the microcontroller.

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