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Hakimjon Zaynidinov
Department of Information Technology, Tashkent University of Information Technologies, Uzbekistan, Address: 108, Amir Temur st., 700087 Tashkent city, Republic of Uzbekistan, Phone:2386437, (98) 3076375,, tet2001@rambler.ru

Sarvar Maxmudjonov
"Bulletin of TUIT: Management and Communication Technologies", s.makhmudjanov@gmail.com

Ruzikulov R.A.
r.ruzikulov@gmail.com

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H.N. Zaynidinov, S.U. Makhmudjanov, R.A.Ruzikulov

Abstract - Among the applications that Internet of Things (IoT) facilitated to the world, Healthcare applications are most important. In general, IoT has been widely used to interconnect the advanced medical resources and to offer smart and effective healthcare services to the people. The advanced sensors can be either worn or be embedded into the body of the patients, so as to continuously monitor their health. The information collected in such manner, can be analyzed, aggregated and mined to do the early prediction of diseases. The processing algorithms assist the physicians for the personalization of treatment and it helps to make the health care economical, at the same time, with improved outcomes. In addition, in this paper, we highlight the challenges in the implementation of IoT health monitoring system in real world.

Keywords: Internet of things (IoT), ECG, EGG, Frequency, COM port, Bluetooth

INTRODUCTION

Internet of Things (IoT) allows to increase the efficiency of medical equipment by real-time monitoring of patients' health, while receiving patient data using special sensors[3]. This technology can continuously receive, monitor and diagnose patient health information. On the Internet, patient parameters are transmitted via medical devices and gateways, then stored and analyzed using a special computer program. A serious problem in the implementation of Internet of Things for healthcare applications is that the Internet is not available to track all patients in different locations. In this study, special attention was paid to the creation of a system that monitors the signals coming out of the gastrointestinal tract of the patient using a specially designed wireless mobile device[1,2,3,4].

The development of wireless mobile technology is providing new solutions for healthcare software applications [6]. Although the system of face-to-face consultation between doctor and patient has never changed, there are medical cases where effective use of wireless technology can be treated in medicine. Wireless transmission technologies are becoming increasingly popular in healthcare and biomedical engineering. Modern wireless technologies of data transmission open up new opportunities for the creators of mobile medical equipment. Recently, a new device called Bluetooth wireless terminal has appeared in our lives. In most cases, this is a small part of the device and is mainly used to provide regular communication via the RS-232 link. In this dissertation work, a prototype of a small built-in EGG touch system was developed using Bluetooth technology. This system is versatile and easily portable[3,5,7,8].

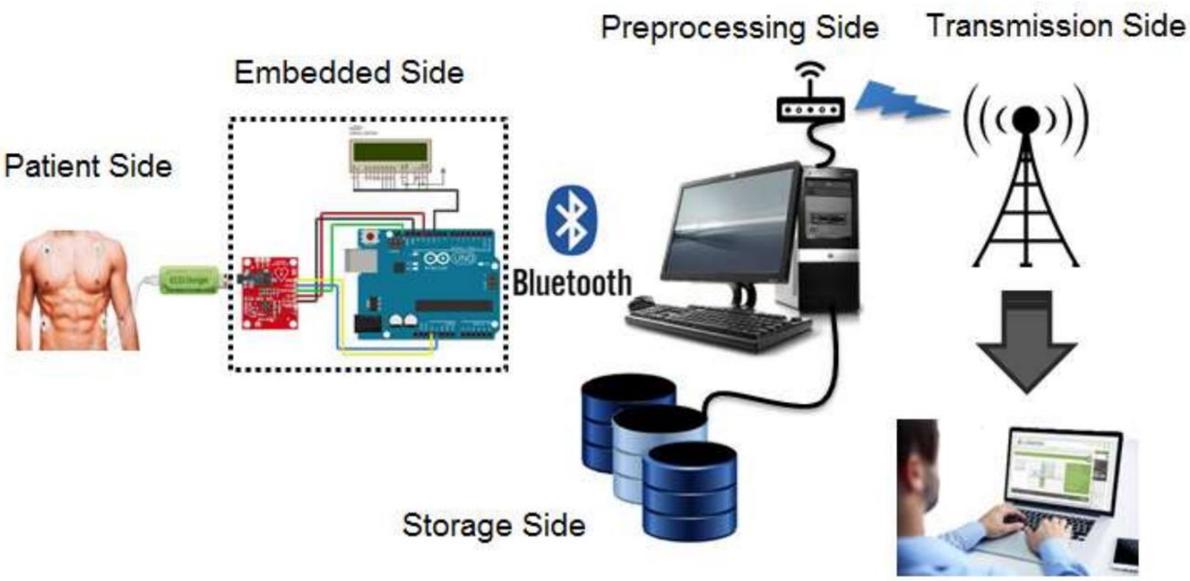

Figure 1. Overall ECG Signal Surveillance System Infrastructure

Electrogastrography (EGG - Electrogastrography) is a method of recording electrical activity in the stomach from cut electrodes placed on the surface of the abdominal cavity. The EGG provides information about the myelectric frequency of the stomach and the amplitude or strength of the EGG signal in the normal or abnormal frequency range. The recording of gastric myelectric activity was described in 1921 by Alvarez [8]. The mid-1970s sparked a new interest in electrogastrography.

Table 1. Signal frequencies emanating from the human body

№	Organs	Frequency range
1	Stomach	0,046-0,051 Hz
2	The duodenum	0,19-0,21 Hz
3	Small intestine	0,13-0,16 Hz
4	The colon	0,09-0,11 Hz

New technical solutions and smart computers have made it possible to record and analyze mede myelectric activity using automated spectral analysis. The non-invasive nature of the technique makes it an important tool in both research and clinical settings. To date, EGG has been used to study a variety of diseases associated with changes in gastrointestinal function [9 - 14]. The main component of gastric myelectric activity is called gastric slow wave or basic electrical rhythm (BER).

This constant low frequency wave is sinusoidal and is usually characterized by its low frequency and low amplitude (100 μV to 500 μV). The dominant frequency of EGG is 0.05 Hz in healthy people or 3 cycles per minute.

The signal from the stomach provides regular anomalies about gastrointestinal disorders and gastrointestinal disorders, as well as diseases associated with nausea and vomiting, anorexia, dyspepsia, and eating disorders. Disorders of AER (stomach upset) can occur in various forms [7]:

an increase in the activity of the myelectric dominant frequency of the stomach at a rate of 3 minutes to 4-9 minutes is defined as tachygastria;

a decrease in the activity of the myelectric dominant frequency of the stomach from 3 minutes to 1-2 minutes is described as bradygastria.

EGG is very sensitive to motion artifacts that are not only strong but also have a broad spectrum, and their frequencies coincide with mede myelectric activity. This makes it difficult to separate them and makes it difficult to qualitatively analyze EGG data. Therefore, automated detection of motion artifacts on the EGG requires an effective solution.

GENERAL STRUCTURE AND ARCHITECTURE OF THE SYSTEM

It basically consists of three modules: the patient's clinical sign-taking and processing module, the medical storage on the mobile computer, and the medical control unit on the server computer. The microcontroller (a specially designed device) receives sensor input signals from three inputs in the air conditioning circuit and transmits them to the laptop in real time based on Bluetooth technology. After transmitting the data to the laptop via the Bluetooth module, it is sent to the hospital (i.e. server) via the internet.

Based on IoT technology, the patient status monitoring system performs the following tasks step by step. The system Electrogastrography (EGG - Electrogastrography) receives the signal from the human body through a specially designed device using sensors and sends it to a mobile computer (laptop) based on Bluetooth technology. The operating sequence of the system is shown in the following diagram:

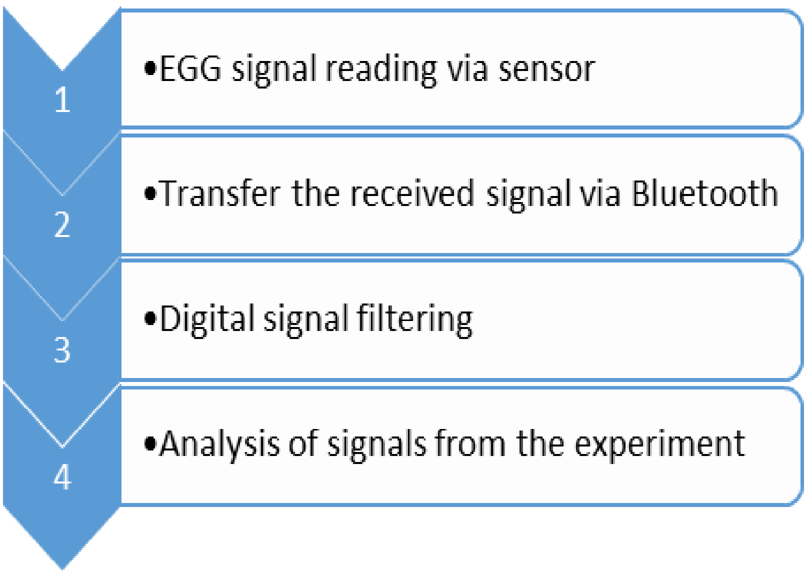

Figure 2. Stages of the process of implementing an EGG signal received from a patient using IoT technology.

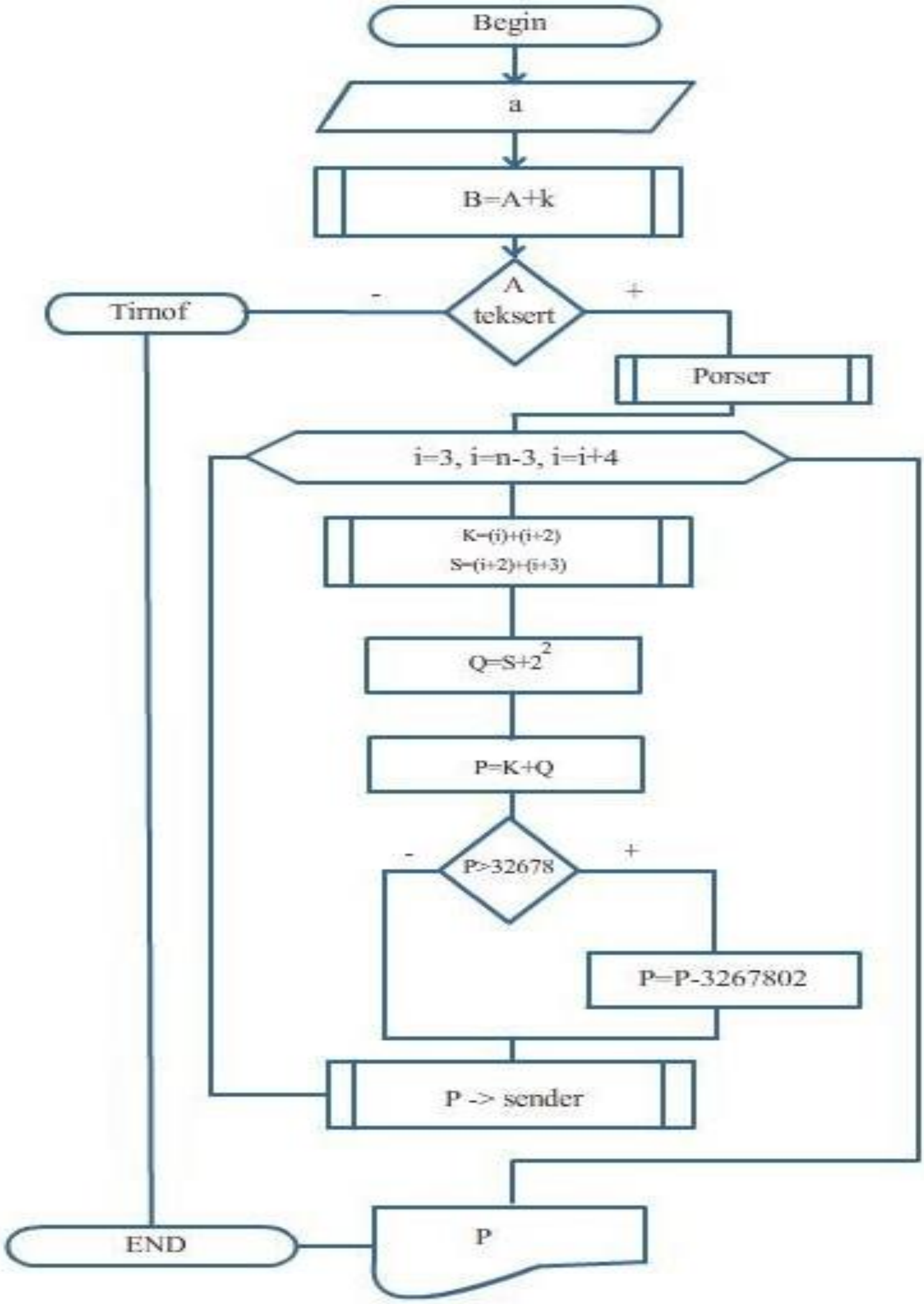

Figure 3. Algorithm for reading data from a mobile device via Bluetooth

There are problems in obtaining experimental data. The reason is that the transmitted EGG signal does not come in the form of a normal frequency (ie Hz).

Maybe the device transmits it in binary view. Also, the transmitted electrical signal does not have a value of "-". It follows that the signal needs to be read and adapted for digital processing. The reading algorithm in Figure 3 was used for adaptation.

The device sends the data in real time to a computer-compatible open COM port. The application reads the data through the COM port.

The transmitted information is also stored in the computer memory in the form of a file as a medical history. It can transfer the saved file to a web server or transfer it in real time.

The research work in this section suggested the application of Bluetooth technology to a wireless EGG signal measurement system and the feasibility of the proposed system. According to our experimental results of the study, the proposed system proved to be expedient. The non-invasive nature of the technique makes it an attractive tool for both research and the clinical setting. The use of an autonomous outpatient system allows the patient to perform his movements freely while receiving signals. Our wireless transmission system allows the data received in the patient's mobile computer memory to be stored and transmitted over the Internet to the hospital's processing department (i.e., the server computer). The patient will no longer need to be in the hospital and the distance separating the patient and the hospital will no longer be limited. As a result, the system is part of the Internet of Things (IoT).

OBTAINING AND VISUALIZING EXPERIMENTAL DATA BASED ON IOT

Wireless networking technologies can help improve the quality of health care. It is widely used in the quality of medical care, medical care management, improving health and service costs, in medical follow-up practices during surgery, as well as in performing the task of communicating with a physician for emergencies.

There are many types of wireless networking technologies. One of them is Bluetooth technology. Figure 4 below illustrates the algorithm for connecting to a computer via a Bluetooth module. Data is transmitted to the computer in serial form, that is, in real time, information is transmitted to the program on the computer without interruption. The computer uses the COM port to receive data. To start receiving software data, you need to make the settings listed in Table 4.1.

The computer sends the data from the serial port to the control unit via the COM port. For such cases, the range of hardware signal reception will be preset.

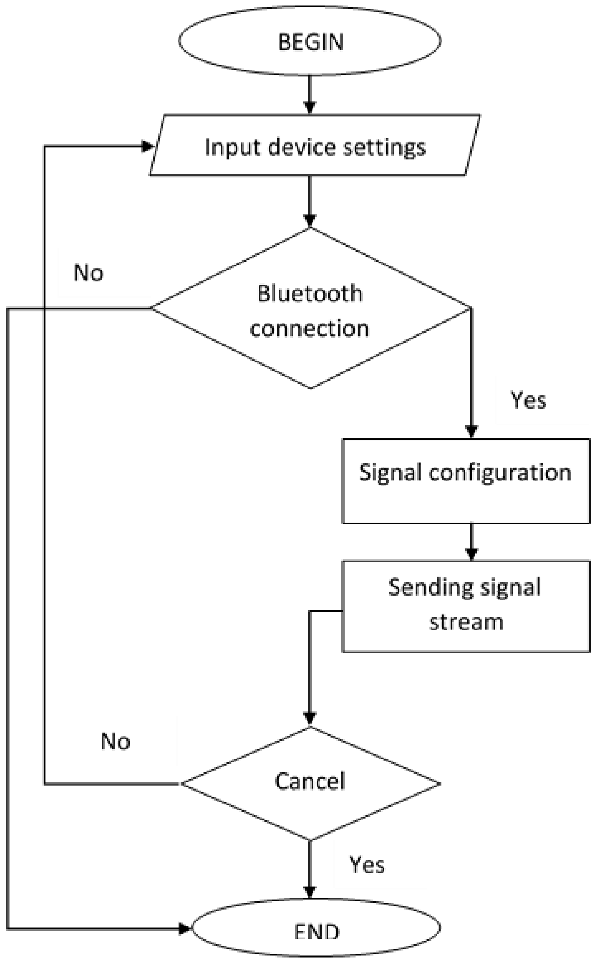

Figure 4. Connect to a computer and transfer data via Bluetooth

Table 2. Configuring a serial port connection

Baud rate	9600
Flow control	None
Data Bits	8
Parity	None
Stop Bit	1

After the process, the connection is created through a special program "Smart health" and real-time data transmission begins. The functional algorithm of the program "Smart health" is shown in Figure 5.

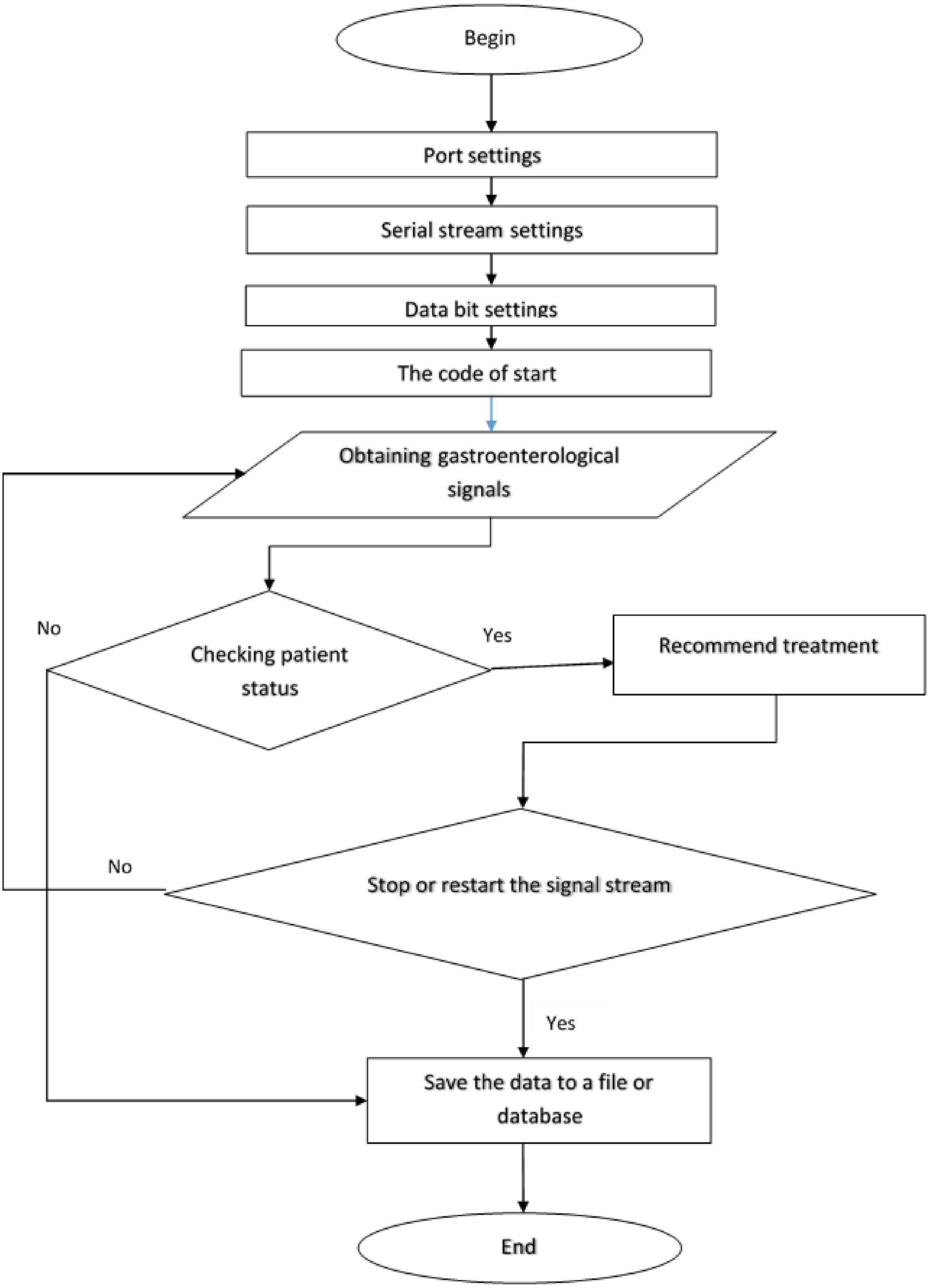

Figure 5. Functional algorithm of "Smart health" program

The Smart health program is designed for input, registration, collection and processing of gastroenterological signals.

- The program includes:
- • Establish a wireless connection with the device via Bluetooth technology;
- • Set the program to receive the signal in the desired range;
- • Automatic input, registration and collection of gastroenterological signal in computer memory;
- • Filtering of gastroenterological signals;

- • Spectral analysis of gastroenterological signals;
- • Determining the required alarm parameters;
- • Demonstration of the results of spectral processing;
- • Settings of the graphical view of the obtained result;
- • Real-time processing and graphical representation of the experimentally received gastroentrological signal;
- • Send necessary and separate analyzes to the cloud server.

The device sends data from the human body to a real-time Bluetooth wireless network technology application, which then processes and depicts it in real-time.

The program menu is divided into two parts (Figure 6): “Serial port settings” and “Data storage”.

In the "Serial port settings" section, you need to make special settings to connect hardware and software. Details of the settings are given in Table 2. In this case, in the "Port" section, select the port from which we receive information, "Flow rate" - a component that determines the speed of communication through the data channel, "data bits" - the data capacity of each packet.

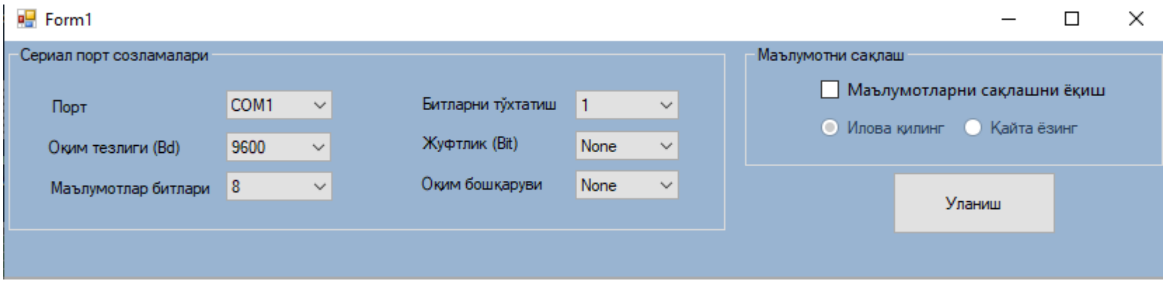

Figure 6. The main settings panel of the program.

Figure 7 appears when you select the appropriate section in the "Data storage" section, and it is enough to specify the values of the gastroenterological signal to which the file is received. In the next step, there are two more options: they have the option to write new data to the file from the beginning, or to continue writing the data from where it came from.

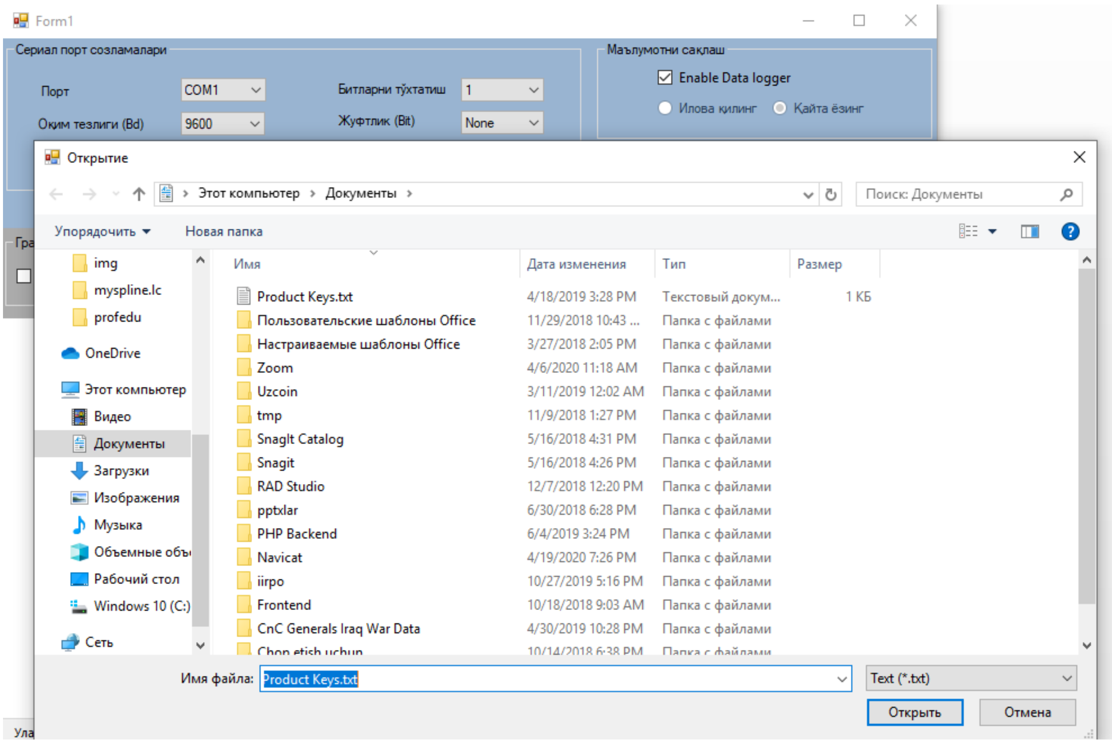

Figure 7. Set to write to a log file.

When all the settings are done, click the "Connect" button. The program then begins to read the serial data coming from the hardware, ie from the COM port, and in real time it is represented graphically to perform the necessary diagnostics. The appearance of the gastroenterological signal received from the human body as an experiment is shown in Figure 8.

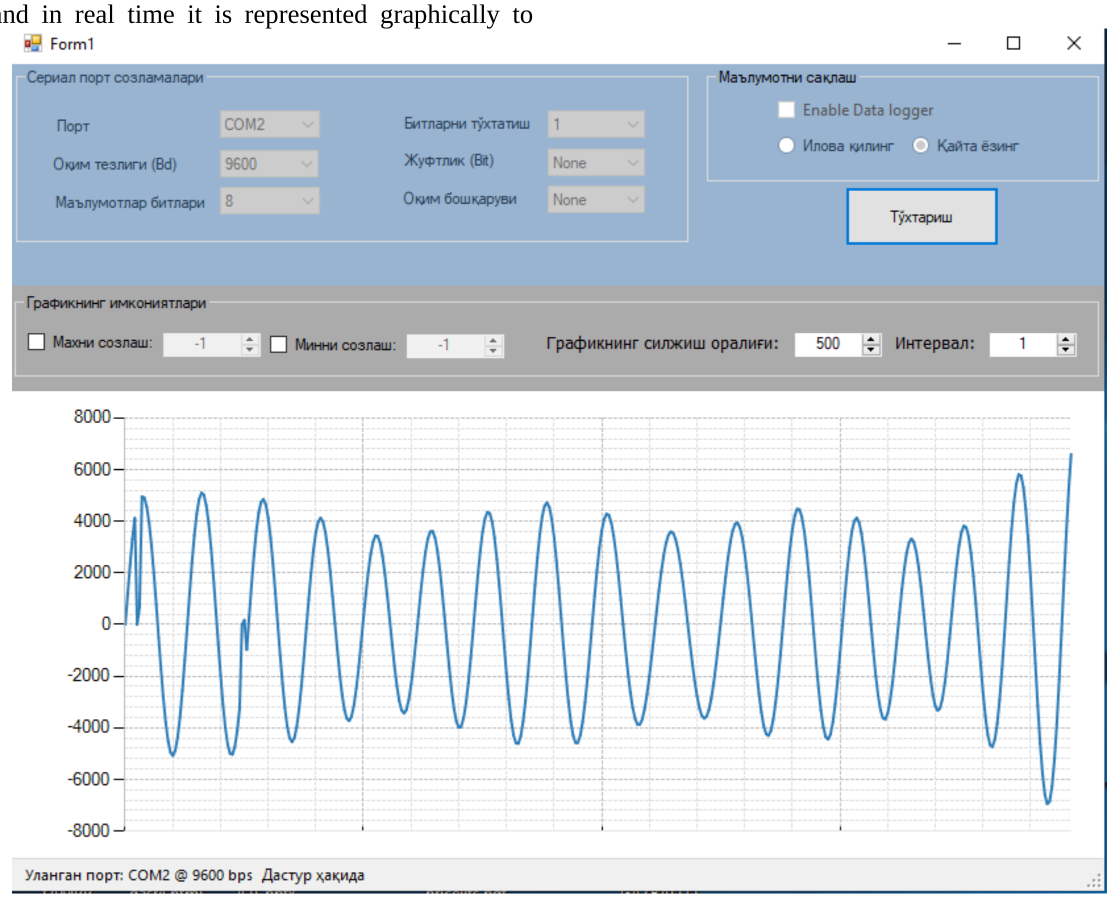

Figure 8. Graph of gastroentrological signal obtained in real time.

Clinical diagnoses show that a signal is always transmitted from the human body within a certain range. If a signal is received throughout the human body (intestine), it is assumed that there are clinical diseases in the part that emits a signal at a lower frequency than normal. The bowel does not work well or almost does not work at certain intervals. Of course, in this case, that part has to be removed surgically quickly. Therefore, in solving the problem, the program allows physicians to determine the appropriate interval at a high level by observing these signals.

CONCLUSION

In the development of this program, the Python programming language was used to read the data flow from the hardware, and the C # programming language was used to visualize them.

The importance and benefits of IoT implementation in remote health monitoring systems have been identified. With IoT, it is possible to monitor each patient in real time via compact sensors.

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