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Municipal Autonomous Educational Institution "Lyceum – Engineering Center" of Soviet district, Kazan City

Practical project

Topic: "Personal doctor fitness bracelet"

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Introduction

The development of science, technology and technology is moving forward every day, having a huge impact on various spheres of human activity, including medicine. Medicine does not stand still. Sophisticated human life support devices, various robots for patient care are emerging in this industry, smart drug delivery is being implemented, and complex operations are being performed that seemed impossible a few years ago.

Promising areas for the development of medicine are automation of the processes of measuring human health indicators and diagnostics, the introduction of highly intelligent analysis methods, including the introduction of robotics. In general, there are several main areas of development of robotics in medicine. On the one hand, this means freeing medical personnel from routine tasks (registering patients, working with electronic records, providing background information), on the other – improving treatment and solving non-standard, complex tasks (for example, using robots in surgery, which makes treatment more effective and less traumatic for the patient, and reduces the risk of complications or the use of programmable nanorobots that can move freely inside the body and pinpoint kill cancer cells).

This paper is devoted to the urgent task of developing a system for monitoring the state of human health, with the possibility of transmitting key parameters to the doctor via the global Internet.

More specifically, in this work, a "Personal doctor Bracelet" is being developed and tested, which will be able to perform certain functions of junior medical personnel, such as:

- Measurement of patient's body temperature;
- Measurement of pulse rate, percentage of oxygen in the blood;
- Taking a patient's cardiogram;
- Measurement of pressure, humidity, and ambient temperature;
- Sending data to the Blynk cloud service;
- Data analysis on the ThingSpeak cloud platform;

- Display of measurement data and their processing on a device connected to the Internet.

Project topic: Personal doctor fitness bracelet.

Its relevance is due to the possibility of practical application of special bracelets for monitoring human health.

Hypothesis: the use of this device is practical and convenient in various fields of activity and everyday life of a person.

Purpose: To develop and test a wristband, write software for the device.

Project objectives:

1. Design and manufacture a wristband for collecting primary health data and transmitting it to the Blynk cloud service;
2. Develop a methodology for interaction between Blynk and ThingSpeak cloud services;
3. Develop a data processing program in the ThingSpeak cloud service;
4. Conduct system tests;
5. Identify the main areas of practical application of the system;
6. Identify areas of development and improvement of the project in the future.

The practical component of the project is environmental assessment and diagnostics of human health.

Chapter I. Development and assembly of the Device

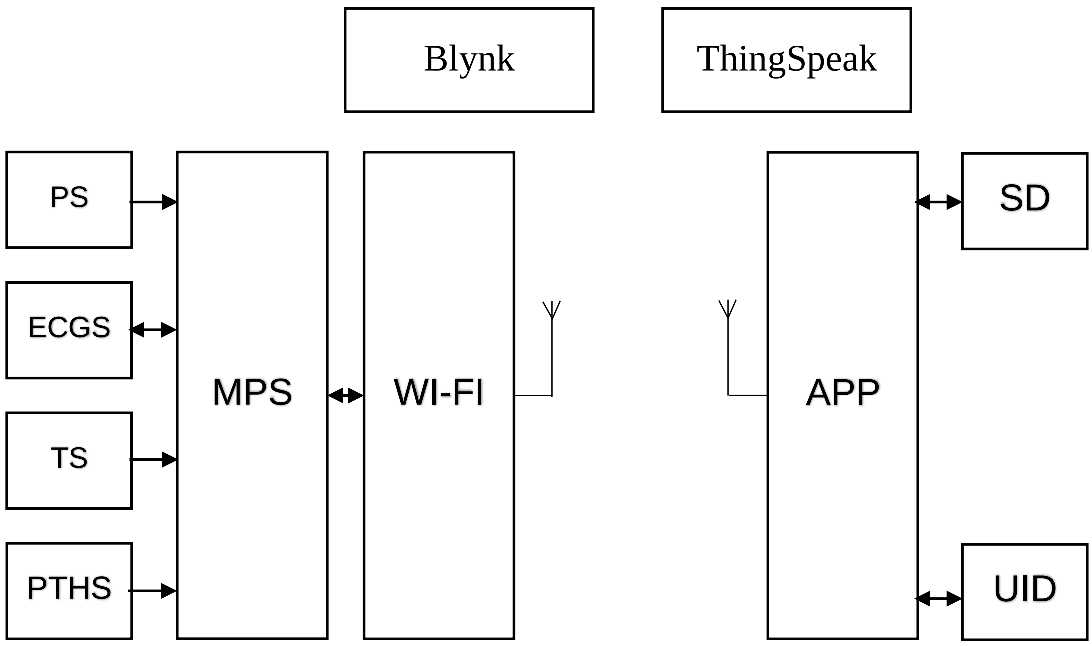

Figure 1 Block diagram of the system under development

The system contains the following main elements: PS-pulse sensor, ECGS-ECG sensor, TS-temperature sensor, PTHS-ambient air pressure, temperature and humidity sensor, MPS-microprocessor data acquisition system, WI-FI-transceiver for connecting to a wireless network, SD-sensor display, UID-user input device, APP – the app on the smartphone, Blynk and ThingSpeak – the remote server.

The system works as follows. The microprocessor system installed on the bracelet determines the parameters that characterize the parameters of human health. The data is sent to the remote Blynk service. Then the received data is sent to the Thingspeak server, where it is analyzed using a program written in MATLAB. The results obtained are transmitted via the Blynk service to a remote device (smartphone or tablet), where they are presented in the form of graphs, tables, and recommendations.

The connection diagram of the sensors to the MPS is shown in Fig. 2.

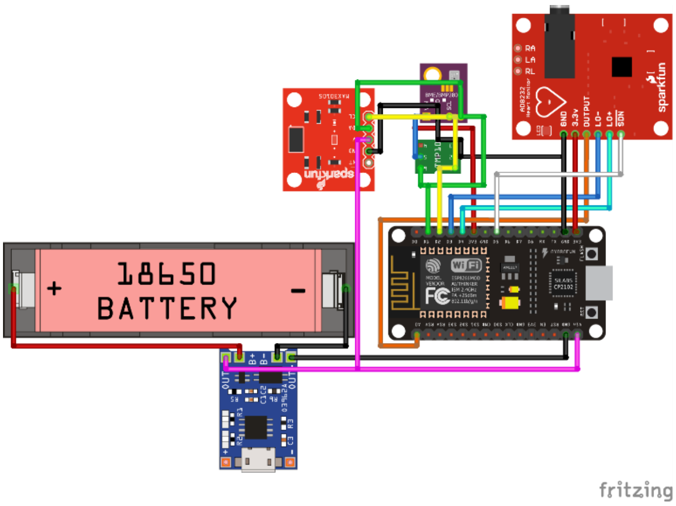

Figure 2 Sensor connection diagram

NodeMCU is the MPS used in this system. The software was created in the Arduino IDE (MPS) and in the Blynk application (APP), respectively. A simplified electrical diagram of the system is shown in Figure 3.

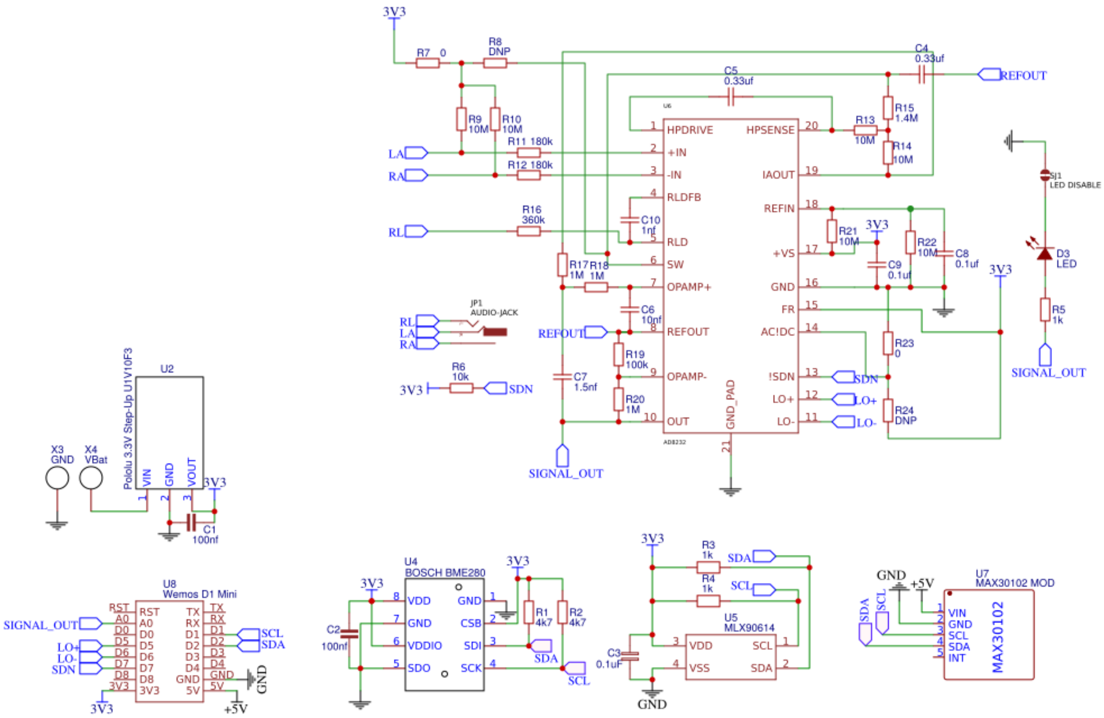

Figure 3 Simplified electrical diagram of the " Personal doctor fitness bracelet" system

Chapter II. Device Software Development

2.1 Writing code for NodeMCU

Since the NodeMCU microcontroller is used, the Arduino IDE will be used as the development environment, in which programs are written in modified C++. Public libraries will also be used, such as SparkFun_MAX3010x_Sensor_Library, BME280, MLX90614, Blynk, BlynkESP8266_Lib, Time. The program performs the functions of collecting data from sensors and transmitting it to the application.

2.2 Creating a mobile app using Blynk

To display data, you need to create Button, Labeled Value, SuperChart, Notification, and Tabs objects to manage the ECGS, display up-to-date data, display changes in parameters over a certain period of time, navigate through the app, and send push notifications when one of the parameters exceeds the norm.

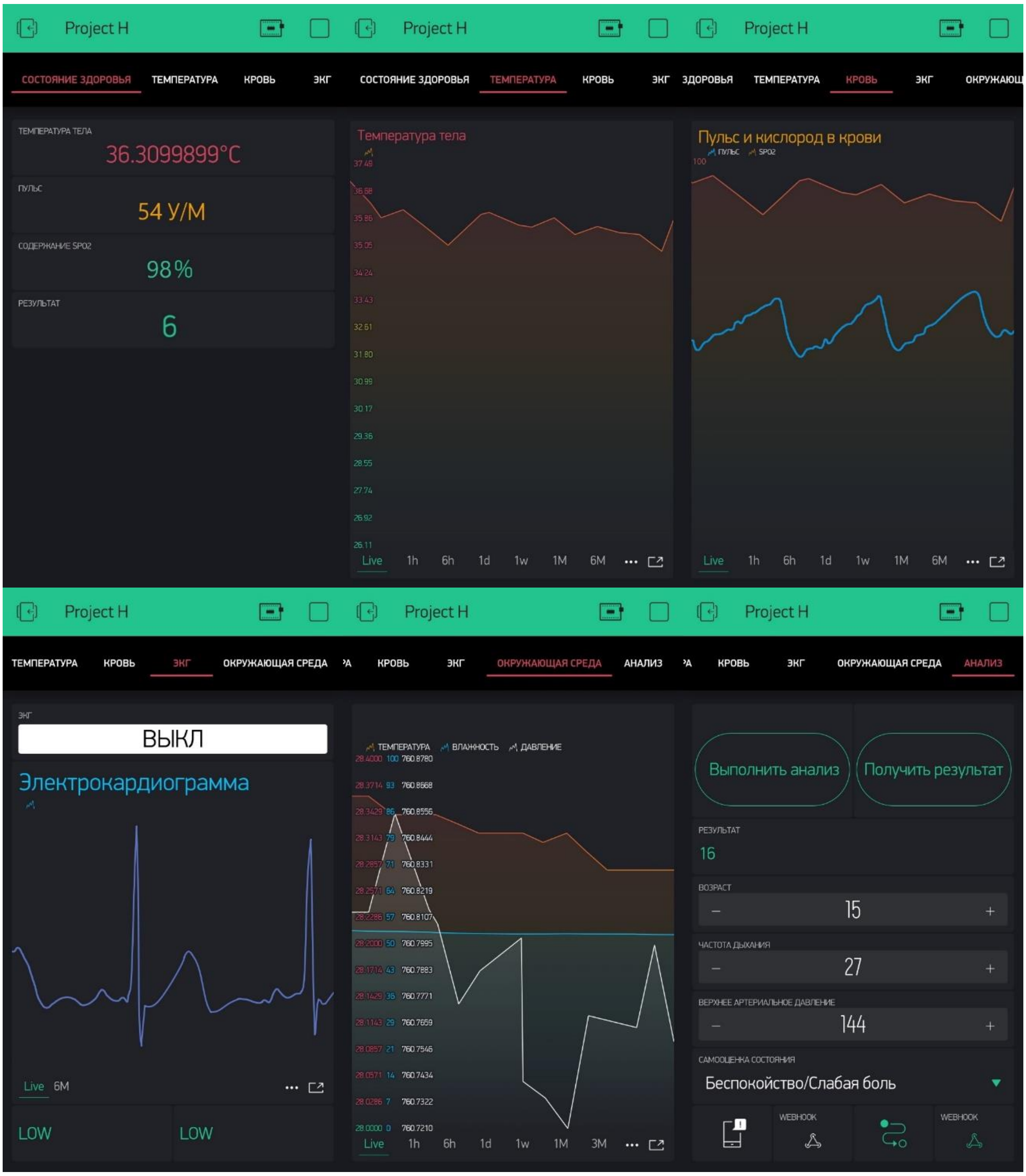

Figure 4 Mobile app appearance

Chapter III. Data analysis

3.1 Medical analysis systems

3.1.1 The MEWS system

Modified Early Warning Score (MEWS) is a guideline used by health services to quickly determine the extent of a patient's illness. It is based on vital signs (respiratory rate, oxygen saturation, temperature, blood pressure, pulse / heart rate, AVPU response). The results were developed in the late 1990s, when studies showed that nosocomial deterioration and cardiac arrest were often preceded by a period of increased impairment of vital functions [1].

Worldwide, MEWS is based on the principle that clinical deterioration can be seen through changes in multiple physiological dimensions, as well as large changes within a single variable. However, the scale is calibrated for different populations and is sometimes extended to include additional parameters specific to different parts of the world. The estimated parameters may vary, as well as weighting the deterioration estimates. Some systems also assign scores to other parameters, including urine output, oxygen saturation, oxygen delivery rate, and pain scores.

There is no consensus on what constitutes an "ideal" early warning assessment system. A comparison of different systems in clinical use shows differences in what parameters are evaluated and how these scores are assigned to different levels of impairment. This has led to calls in several countries to develop a national early warning indicator that would standardize the approach to assessing and responding to deteriorating patients.

Score	3	2	1	0	1	2	3
Respiratory rate	<8	9	9-10	11-14	15-20	21-30	>30
SpO2	<85	85-89	90-92	>92			
Extra oxygen is supplied		Yes		No			

Temperature	<34	34-34.9	35-35.9	36-37.9	38-38.9	>38.9	
Blood pressure	<70	70-79	80-99	100-199		>199	
Heart rate	<30	30-39	40-49	50-99	100-109	110-129	>129
Self-assesment	No consciousness	Pain	Anxiety	Calmness			

Table 1 MEWS

3.1.2 The PEWS System

Pediatric Early Warning Score (PEWS) are clinical signs that indicate the condition of children from infancy to adolescence. The PEWS Score or PEWS System is an objective assessment tool that includes the clinical manifestations that have the greatest impact on a child's outcome. [2] [3]

It was developed based on the success of MEWS in adult patients to match the vital parameters and manifestations seen in children. The goal of PEWS is to provide an assessment tool that can be used by multiple specialties and departments to objectively determine a patient's overall status. The goal of this is to improve communication within teams and between fields, recognition and patient care times, and morbidity and mortality rates. Monaghan created the first PEWS based on MEWS, interviews with pediatric nurses, and observations of pediatric patients

Several PEWS systems are currently in use. They are similar in nature, measuring the same domains, but differ in the parameters used to measure domains. Thus, some of them were more effective than others, but all of them were statistically significant in improving the timing and outcomes of patient care [4] [5].

Показатель	3	2	1	0	1	2	3
Respiratory rate	<8	9	9-10	11-14	15-20	21-30	>30

SpO2	<85	85-89	90-92	>92			
Extra oxygen is supplied		Yes		No			
Temperature	<34	34-34.9	35-35.9	36-38.3	38.3-38.9	>38.9	
Blood pressure	<70	70-79	80-99	100-199		>199	
Heart rate	<50	50-57	57-65	65-100	100-109	110-120	>120
Self-assesment	No consciousness	Pain	Anxiety	Calmness			

Table 2 PEWS for children aged 13-16 years

3.1.3 ECG interpretation

ECG interpretation is mainly about understanding the electrical conduction system of the heart. Normal conduction begins and propagates in a predictable pattern, and a deviation from this pattern can be a normal change or a pathological one. The ECG does not correspond to the mechanical pumping activity of the heart. Certain rhythms are known to have good cardiac output, and some have poor cardiac output. Ultimately, an echocardiogram or other anatomical imaging technique is useful in assessing the mechanical function of the heart [6].

Like all medical tests, what constitutes "normal" is based on population-based studies. A heart rate range of 60 to 100 beats per minute is considered normal because the data shows that this is a normal resting heart rate

To briefly summarize the components of a normal ECG trace, it consists of waveform components that indicate electrical events during a single heartbeat. These signals are labeled P, Q, R, S, T, and U.

The P-wave is the first short upward movement of the ECG. This indicates that the atria are contracting, pumping blood to the ventricles.

The QRS complex, usually starting with a downward deviation, Q; a larger upward deviation, peak (R); and then a descending wave S. The QRS complex represents depolarization and ventricular contraction.

The PR interval indicates the time of passage of an electrical signal from the sinus node to the ventricles.

The T-wave is usually a moderate ascending waveform representing ventricular repolarization [7].

3.2 Transmitting and analyzing data with Thingspeak

When the button is clicked, the data is collected in a single variable and transmitted via the Blynk WebHook widget to the Thingspeak server.

Then they are analyzed using EWS (early warning score) systems depending on their age. EWS systems are a set of different standards of indicators that determine the need for medical intervention. We will use PEWS (pediatric early warning score) for children up to and including 16 years of age and MEWS (modified early warning score) for children over 16 and adults.

If various factors deviate from the norm, points are increased. The more points scored, the greater the need for medical intervention.

The data is then analyzed using the MATLAB programming language and sent back to the application using another WebHook.

Chapter IV. Testing the bracelet

4.1 Research results

The system was tested on my family members. The following people took part in the testing: Gazizullin Niyaz Nailevich (Father), Gazizullina Nailya Rafailovna(Mother), Gazizullina Ilvina Niyazovna (Younger sister), Gabdrakhmanova Sofya Gabdulovna (Grandmother), Gabdrakhmanov Rafail Rakhimzyanovich (Grandfather). The results of the study are shown in Table 3.

Test subject	Indicators						
	Respiratory rate	SpO2	Extra oxygen supply	Temperature	Blood pressure	Heart rate	Self-assesment
Damir	10	95	No	36,7	145	79	Calmness
Father	13	99	No	36,6	140	80	Calmness
Mother	15	94	No	37,1	137	86	Anxiety
Sister	12	96	No	36,9	134	68	Calmness
Grandmother	10	93	No	36,4	190	113	Calmness
Grandfather	12	93	No	36,5	174	91	Calmness

Table 3 Determination of body temperature and pulse rate of subjects

The results obtained and the well-being of the father and younger sister indicate that they were absolutely healthy at the time of the test.

The increased temperature and rapid pulse of the mother indicated certain health abnormalities, which was confirmed by the diagnosis of acute respiratory viral infections established by the doctor.

A significant deviation of the grandmother's pulse readings from the norm indicates a pathology of the heart and age-related changes, which is confirmed by her diagnosis: Cardiomyopathy of mixed genesis, Tricuspid regurgitation of 2-3 degrees, Aortic regurgitation.

Air temperature and atmospheric pressure in the room were also measured before and after ventilation. The results obtained are shown in table 4.

Condition of the room	Indicators		
	Air Temperature (℃)	Air pressure (mmHg)	Humidity (%)
Before air cycling	26	780	60
After air cycling	21	780	70

Table 4 Changes in ambient air temperature and atmospheric pressure

4.2 Defining the main areas of practical application

Based on the research results, we have identified a number of areas and areas of human activity where the practical use of the Personal doctor fitness bracelet is possible and appropriate.

1. In medical institutions. The device can be used as a robot assistant that performs a number of simple operations: measuring the patient's body temperature; measuring the pulse rate; measuring pressure, humidity, air temperature, oxygen percentage in wards and functional rooms, as well as performing certain functions and facilitating the work of junior medical personnel.

2. In everyday life. Anyone using the Personal doctor fitness bracelet can measure their body temperature and pulse rate, as well as determine the qualitative and quantitative characteristics of indoor and environmental air and send readings to the attending doctor using Wi-Fi.

3. In cosmonautics. Only healthy people go to space. However, no one is immune from unforeseen complications in the body. With the help of the bracelet, an astronaut will be able to measure their body temperature and pulse rate, as well as measure pressure, humidity, air temperature, and oxygen content in the air on the space station or inside the spacecraft during flight.

4. People of certain professions. For example, drivers of public and freight transport are required to pass a medical check-up before getting on a flight.

4.3 Determining the direction of development and improvement of the project in the future

In this case, a prototype of a remote human health monitoring system was created, which is able to perform certain functions of junior medical personnel, such as:

- Measurement of patient's body temperature;
- Measurement of pulse rate, percentage of oxygen in the blood;
- Taking a patient's cardiogram;
- Measurement of pressure, humidity, and ambient temperature;
- Sending data to the Blynk cloud service;
- Data analysis on the ThingSpeak cloud platform;
- Display of measurement data and their processing on a device connected to the Internet.

In the future, it is planned to expand the capabilities of the device, giving it the ability to measure blood pressure, measure the number of breaths and exhalations per minute. To do this, you need to install and program a blood pressure sensor, a spirometer. It is also planned to introduce adaptive changes in the diagnosis into the device, depending on the norms of indicators of a certain person.

Conclusion

Science is part of nature. With advances in science and many growing technologies at the forefront, robotics in medicine is a promising field of modern science, making a great contribution to human life from birth to the afterlife in seven forms, thus gracefully depicting a scientific rainbow in the hospital environment.

The introduction of robotics in various fields of medicine is a promising area of medical development.

The use of medical robots provides a wide variety of positive effects:

- increasing the level of automation facilitates the work of doctors, increases their productivity, can provide access to fundamentally new levels of capabilities (increasing the complexity of available operations, reducing the invasiveness of operations and other types of treatment, as well as the likelihood of medical errors);

- reducing the cost of secondary and junior medical personnel, facilitating the work of these personnel, including pharmacists;

- intensification of the processes of patients ' return to normal existence after injuries, diseases, operations;

- increasing the mobility of low-mobility groups of the population;

- facilitating survival for elderly patients;

- facilitating the stay of patients in hospitals, smoothing out the problems associated with the" separation " of patients from their usual social circle, from family, providing contacts or remote monitoring of the patient in the hospital or an elderly person at his home by family members who may be located elsewhere;

- others.

In this work, a system for remote monitoring of human health has been developed that can monitor a number of parameters: patient's body temperature, heart rate, blood pressure, humidity, and ambient temperature. The system can display key parameters on the screen, analyze them, and transmit the necessary information to the attending physician via the Internet. The simplicity of the device and its portability allow the system to be used not only in medical institutions, but also in everyday life and are designed to provide better control over the state of people's health.

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