# DEVELOPMENT OF A "SALIVA" HARDWARE-SOFTWARE COMPLEX MODULES FOR THE PRIMARY DIAGNOSIS OF GASTROINTESTINAL DISEASES

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***Abstract.*** *The article deals with the issues of diagnosing gastrointestinal diseases based on human saliva. The results obtained in solving the problems of identifying and primary diagnosis of gastrointestinal symptoms as a result of a change in the composition of saliva were analyzed and the results obtained were compared with the results obtained in the works of other scientists.*
***Keywords:*** *Saliva device, sensor, ADC, UART, LM2596 controller, Bluetooth.*

## Introduction

Currently, many modern solutions have been developed to detect diseases in human saliva at any time of daily activities. In each of the proposed solutions, the hardware and software of devices is used to detect symptoms of various types of diseases, diagnose or remotely monitor certain diseases.

This article presents an analysis of the 7-channel hardware-software complex "Saliva" for the primary diagnosis of gastroenterological diseases.

This hardware and software complex, designed for the population living outside medical institutions or hard-to-reach areas, was developed in accordance with the following requirements:

Availability of equipment and software for primary diagnostics;

The device can be used at home and by gastroenterologists for daily activities;

Cheap enough for everyone;

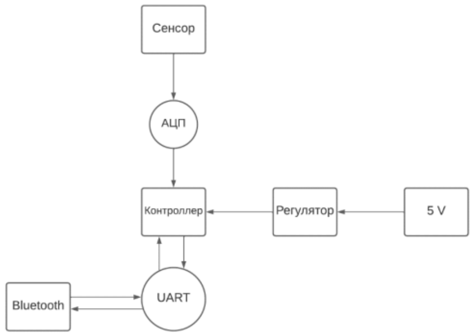
Long-term operation of the power supply;

## Development of hardware-software complex modules

Devices for the primary diagnosis of diseases of the gastrointestinal tract is called "Saliva". The device consists of sensor, ADC, microcontroller, UART, Regulator and Bluetooth. When developing the Saliva device, special attention was paid to its low cost and ease of carrying.

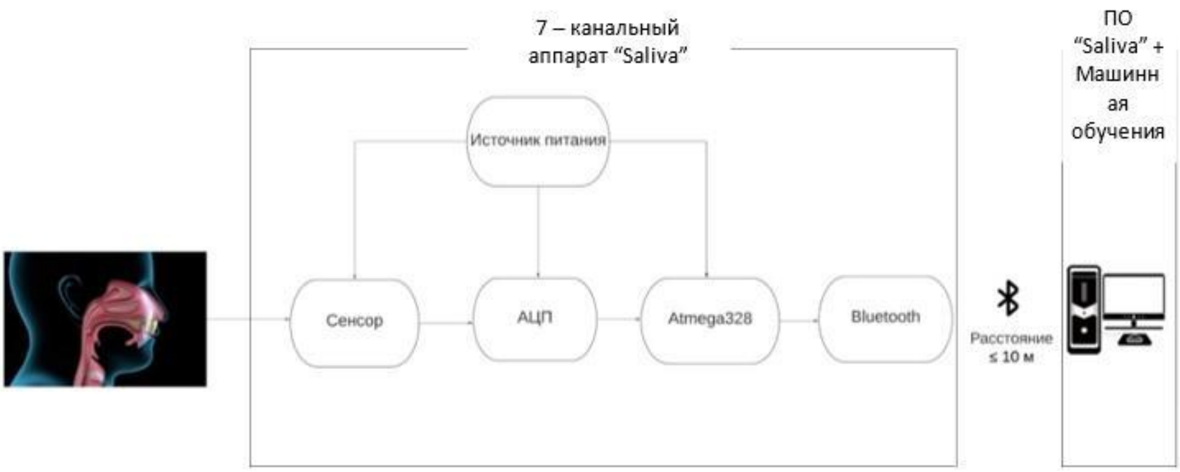
The architecture of the "Saliva" system consists of functional blocks and each performs certain tasks, Figure - 1.1. The "Saliva" system consists of 5 main modules, and they make up the hardware-software complex [1-4].

Fig 1.1.




Functional module of the “Saliva” device.

Fig 1.2.




Structure of the 7-channel hardware-software complex “Saliva”

Figure 1.2 shows the structure of the 7-channel hardware-software complex “Saliva”, which consists of 5 main modules, together with them it makes up the hardware-software complex of the device.

Based on the structural image of the Saliva hardware-software complex, we can distinguish the main modules as:

Sensors - according to the selected parameters, it makes up a set of sensors for protein, glucose, mucin, cholesterol, ammonium and uric acid. Here, the sensor performs the task of both obtaining a substance for analysis and a recognizer for subsequent processes. Since, using the example of human saliva, we know about its content of substances and enzymes.

An analog-to-digital converter (ADC) is a device that converts an input analog signal into a discrete code, that is, converts it into a digital one. In the ADC chip, all channels are discredited simultaneously. The gain parameters of the ADC chip can be adjusted by the PGA.

PGA at a Glance - Digital Programmable Gain Instrumentation Operational Amplifiers (PGAs) are versatile input op-amps that digitally control gain to improve accuracy and increase dynamic range [9-12].

After the sensor determines all the constituent components of saliva as an analog object, the information is transmitted precisely to the ADC, as mentioned above. The ADC converts the information received from the sensor into a binary code. This chip allows you to measure the patient's saliva according to the selected parameters, can use the RLD scheme, the data transmission of the chip can reach a speed of 500-32 kbps (the value of the transmitted discrete frequency is 103 seconds). The connection between the “Saliva” device and the computer is established through the UART interface.

**Atmega328 microcontroller.** ATMega328 microcontroller is 8-bit CMOS low power microcontroller based on advanced AVR RISC architecture. The microcontroller receives the primary processed signal of the saliva sample coming from ADS1298 chips in the power supply of the “Saliva” device, performs secondary processing, and transfers them to the Bluetooth module via the SPI interface. The microcontroller also controls the ADC module, a 7-channel device for a discrete and analog-to-digital saliva sample signal converter and other peripheral devices. Communication between the Atmega328 and peripherals was implemented using the SPI module. Block diagram of the Atmega328 microcontroller.

The Atmega328 microcontroller is connected to two SPI interfaces that support high-speed data exchange with ADC and Bluetooth NS-05 devices. The ADC module provides a serial communication clock system. Synchronization in all communication processes should be at least minimal.

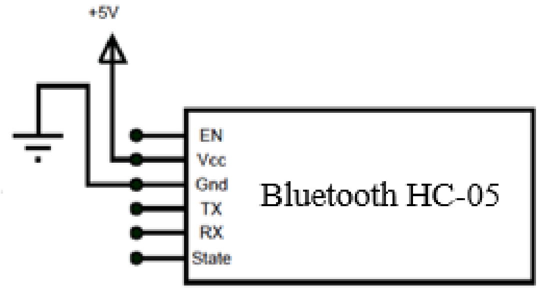
Fig 1.3.

Atmega328 microcontroller.


**Bluetooth HC-05.** Bluetooth HC-05, one of the main power modules of the “Saliva” device, provides the process of wireless data exchange between the computer and the “Saliva” device via the UART interface. The frequency range of the HC-05 module and the data transmission channel correspond to ISM, i.e. 2.4 GHz. This intermediate frequency is the radio frequency range defined by the radio regulations of the International Telecommunication Union.

Figure 1.4.

Block diagram of Bluetooth module HC-05




The total size of information of 8 channels coming from the ADS1298 device is 224x8 = 224x23=227, that is, 227x50/8 = 838 860 800 or 838 860 800/1024 = 819 200 Kbps or 800 Mb.

If this value is expressed in the 16th number system, it will be equal to 800/216=0.0122 MB. The total bandwidth of the Bluetooth NS05 device selected for designing the ECG device is 2.1 Mbps, which is about 10 times more than the digital data (0.0122 Mbps) generated by the ADC device, which is in line with the current demand [5-8].

Bluetooth HC-05 has two different states (modes): command state and transmit/receive state. 38400kbps in command mode and 9600kbps in data transmission/reception mode.

Hardware-software complex “Saliva” is shown Fig. 1.5. The “Saliva” hardware and software complex was developed jointly with gastroenterologists at the clinic of the Tashkent Medical Academy. The functional structure of the Saliva hardware-software complex is shown in Figure 1.6.

Functional structure of the hardware-software complex "Saliva":

1. Sensor - 7 channel saliva sensor
2. ADS1298 - ADC (analogue-to-digital converter);
3. Atmega328 - microcontroller;
4. Bluetooth HC-05 - Acts as a wireless module between Saliva device and computer.
5. LM2596_5V - Linear regulator developed by Texas Instrument for small devices.
6. External power supply.

Fig 1.5.

Hardware-software complex “Saliva”

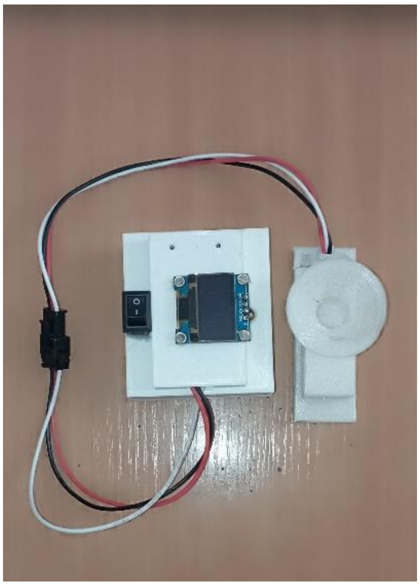
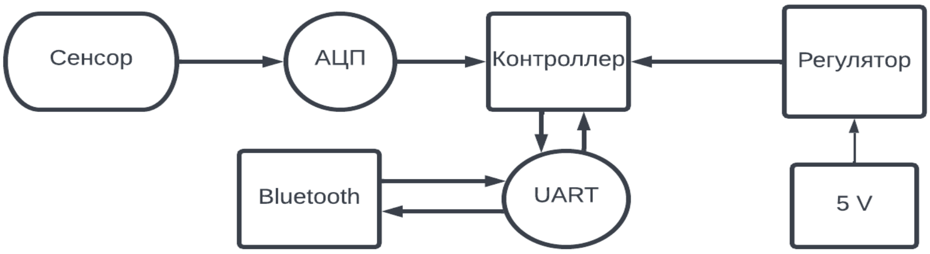


Fig. 6.

Functional structure of the hardware-software complex "Saliva"




**Results**

*Table 1.*

*The composition of the saliva of a healthy person*

| № | The composition of saliva | Qty. (% and g/l) |
|---|---|---|
| 1 | Water | 99,4-99,5 % |
| 2 | Organic and inorganic components | 0,5-0,6 % |
| 3 | Squirrels | 1,4-6,4 г/л |
| 4 | Mucin | 0,8-6,0 г/л |
| 5 | cholesterol | 0,02-0,5 г/л |
| 6 | Glucose | 0,1-0,3 г/л |
| 7 | Ammonium | 0,01-0,12 г/л |
| 8 | Uric acid | 0,005-0,03 г/л |

Table 1 shows the composition of the saliva of a healthy person, from the composition of a healthy person, 6 parameters were selected with gastroenterologists for further scientific research.

The selected parameters for the study are indicated in Table 2.

*Table 2.*

*Selected parameters for the study*

| Data set parameters | The name of the composition of saliva |
|---|---|
| Parameter_1 | Squirrels |
| Parameter_2 | Mucin |
| Parameter_3 | cholesterol |
| Parameter_4 | Glucose |
| Parameter_5 | Ammonium |
| Parameter_6 | Uric acid |

With the help of the selected parameters, a database of patients was created, that is, huge data on patients was needed for research. The Random Forest (RF) machine-learning algorithm has been upgraded. An algorithm for data exchange from the Saliva hardware-software complex to a smartphone or computer has been developed (Fig. 7) [].

As a result of joint work with specialists, 5000 sample data were collected for primary diagnosis. With the help of the modernized Random Forest (RF) machine learning algorithm, the process of learning the sample data of patients was done, as a result, the accuracy of the primary diagnosis showed 98% in 2 minutes [13-15].

With the help of the developed hardware-software complex "Saliva" it is possible to speed up the process of primary diagnostics. The developed hardware-software complex “Saliva” can become an assistant to a gastroenterologist, ambulance specialists and medical staff of family clinics. Table 3 shows a detailed analysis of hardware and software systems in gastroenterology [16-19].

Fig 7.

Steps for communication and data exchange between Saliva equipment and computer

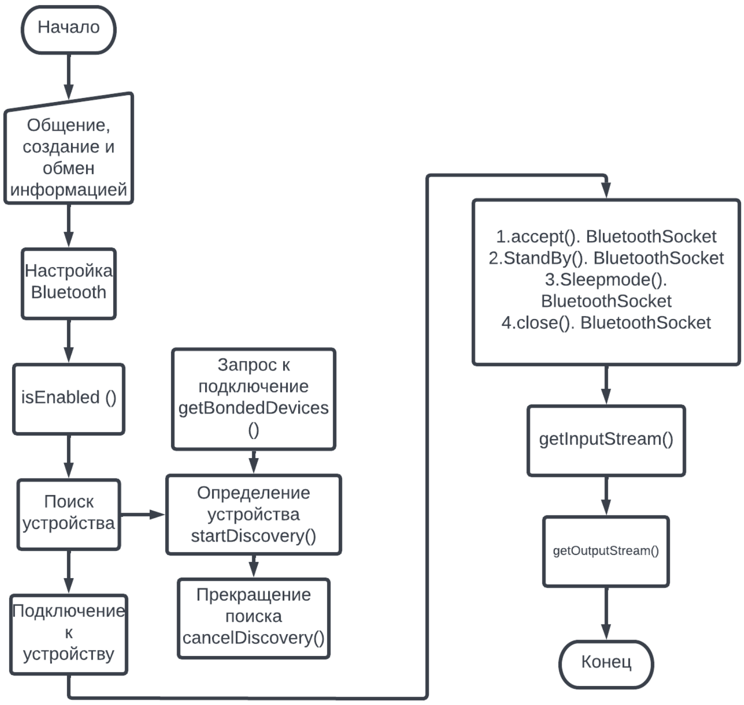



*Table 3.*

*Analysis of hardware-software complexes of primary diagnostics*

| № | Device name | Price | Diagnosis time | Accuracy diagnosing |
|---|---|---|---|---|
| | Gastroscope | 14.5 million sum | 30 minutes | 70% |
| | Gastroduodenoscope | 40 million sum | 20 minutes | 80% |
| | Duodenoscope | 66 million sum | 15 minutes | 82% |
| | Esophagoscope | 72 million sum | 20 minutes | 84% |
| | Colonoscope | 420 million sum | 10 minutes | 90% |
| | Videogastroscope | 61 - 150 million soums | 10 minutes | 85% |
| | Thin gastrofibroscope | 90 million sum | 25 minutes | 80% |
| | Gastrofibroscope | 138 million sum | 20 minutes | 86% |
| | Cystofibroscope | 112 million sum | 20 minutes | 81% |
| | Gastroenteromonitor | 7.5 million sum | 21 minutes | 72,50% |
| | Gastromanometer | 71 million sum | 10 minutes | 84,50% |
| | Acid gastrometer | 71 million sum | 3 hours | 85,50% |
| | Acidogastromonitor | 71 million sum | 3 hours | 86,50% |
| | Saliva | 3 million sum | 2 minutes | 98% |

**CONCLUSION**

As a result, we can say that with the help of this developed hardware-software complex, it is possible to reduce the time of diagnosis. The hardware-software complex can be further used in polyclinics and as an auxiliary complex for a gastroenterologist. This device is mainly used for preliminary diagnosis as a test for children and patients who experience discomfort when swallowing a tube.

Devices called "Saliva" are created using the latest technology, that is, using an artificial intelligence algorithm based on deep machine learning, preliminary diagnostics are carried out and high-precision results are obtained from patients.

The hardware and software complex was developed jointly with the 2-clinic of the Tashkent Medical Academy, with gastroenterologists.

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