Telemedical Monitoring of Body Temperature: Application in Clinical Practice

Leonid A. Melnikov, Alexander A. Bolshakov, Valeriy V. Bakutkin

For citation:
Melnikov L.A., Bolshakov A.A., Bakutkin V.V. Telemedical Monitoring of Body Temperature: Application in Clinical Practice. *Scientific Research and Innovation. 2021;1(2):44–47*
DOI:10.34986/MAKAO.2021.98.61.001

Authors' credentials:
Melnikov, Leonid A., Doctor of Physics and Mathematics, Professor, Gagarin State Technical University of Saratov

Bolshakov Alexander A., Doctor of Technology, Professor, Peter the Great St.Peterburg Polytecnic University, Institute of applied Mathematics and Mechanics, RF
Rinz: 692467
Researcher ID: N-5819-2016
Scopus Author ID: 56432582600
SPIN-код: 4098-0738

Bakutkin Valeriy V., Doctor of Medicine, Intemsis, LLC, Saratov, RF

Conflict of interest:
The authors declare that they have no conflicts of interest.

Received: 10 March 2021
Revised: 21 March 2021
Published: 20 May 2021

Abstract: We present the results of investigating the use of remote digital sensing technology for diagnosing the body temperature. We developed the remote telemedicine system for monitoring body temperature on the basis on modern information technology. The appliance is described in detail in our paper. It has high accuracy, safety, reliability, small dimensions, and low power consumption.

Keywords: Telemedical monitoring, body temperature, clinical practice application, diagnostics, spline

Introduction

Body temperature is of great importance in diagnosis of many ailments. Measuring body temperature is one of the oldest medical procedures. Galen reported in the 5th century BC that Hippocrates used these data to describe diseases. The first temperature measurement with a mercury thermometer was made over 100 years ago (Harvey Cushing, 1895). Mercury-based glass thermometers do not meet modern requirements. In addition, spilled mercury is extremely toxic. In 2007, the use of devices containing mercury was banned throughout the European Union. At present, it is necessary to create remote telemedicine systems for monitoring body temperature using contemporary information technologies. When developing such devices, the main requirements are high accuracy, safety, reliability, small dimensions and low power consumption [7].

The goal of our study is the development of a telemedicine system for monitoring body temperature and its application in clinical practice.

Materials and Methods

We have developed a high-speed thermometer with a wireless data transmission channel, thus implementing a method for measuring temperature by integral values. The device has an increased operating time (100 hours) with a measurement time of 1–2 s and an error of no more than ±0.1 °C. It can be used in medical systems for monitoring the parameters of the human body [2].

The solution to the problem of remote temperature monitoring was achieved by using a novel device in the system in the form of a portable autonomous measuring and transmitting module. The latter is a high-speed digital temperature sensor with a built-in wireless module for data transmission of the Wi-Fi standard, a data consolidation server (computer) equipped with a wireless Wi-Fi interface with specialized software for collecting, storing and displaying accumulated monitoring data, and a Wi-Fi router providing wireless data exchange. Monitoring of a body temperature is possible for any patient of medical institutions and other facilities equipped with wireless data transmission of the Wi-Fi standard, in order to develop a diagnostic schedule for the patient, as well as for automated analysis and assessment of the body temperature dynamics. The block diagram of the appliance is presented in Figure 1.

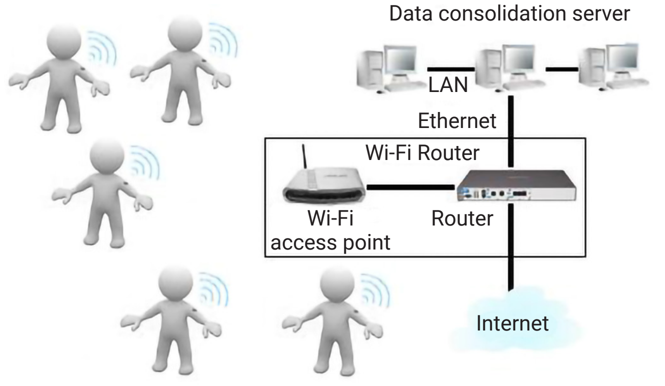


Figure 1. Block diagram of the appliance

Component composition of the system and its structure provides temperature monitoring in a large number of patients, with the ability to analyze, store and transmit data via wireless communication channels.

Results

The system works as follows: a portable measuring and transmitting module (Figures 2 and 3) periodically measures the temperature of the human body by means of a temperature measurement sensor at least once every 15 minutes.

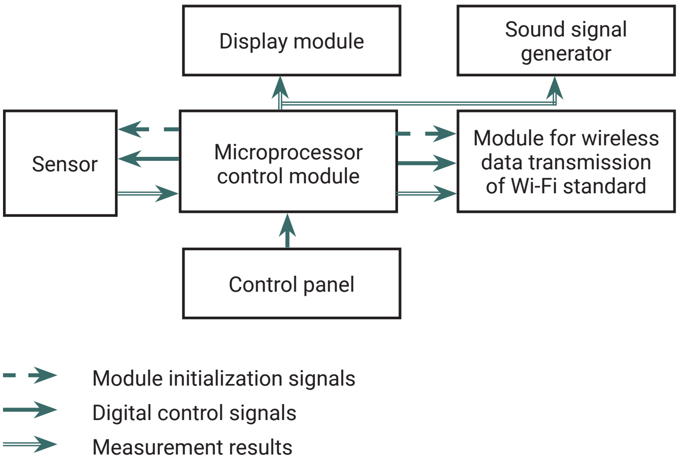


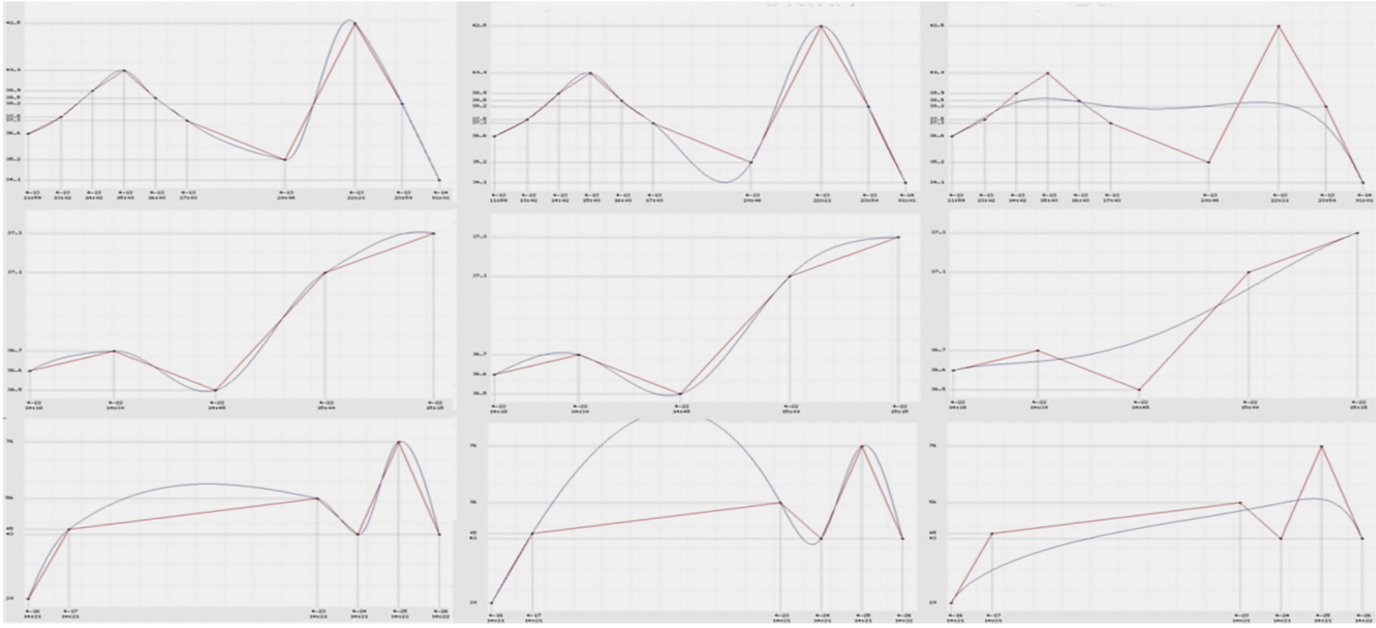
Figure 2. Functional diagram of the measuring and transmitting module

The temperature measuring sensor, the parameters of which are initialized by the microprocessor control module (hereinafter referred to as the MCM), measures the temperature of the human body on command and transmits the result to the MCM. The module for wireless data transmission of the Wi-Fi standard, the parameters of which are initialized by the MCM, upon the MCM command, transfers the temperature measurement results over the wireless Wi-Fi network to the data consolidation server via a Wi-Fi router. The specialized software allows saving monitoring data in an information database, conducting retrospective analysis, performing an on-line analysis of temperature curves (Figure 4), and supporting the functions for registering and authenticating users in the system in accordance with their personal profiles (Figure 5).

Figure 3. Measuring and transmitting module: the device appearance

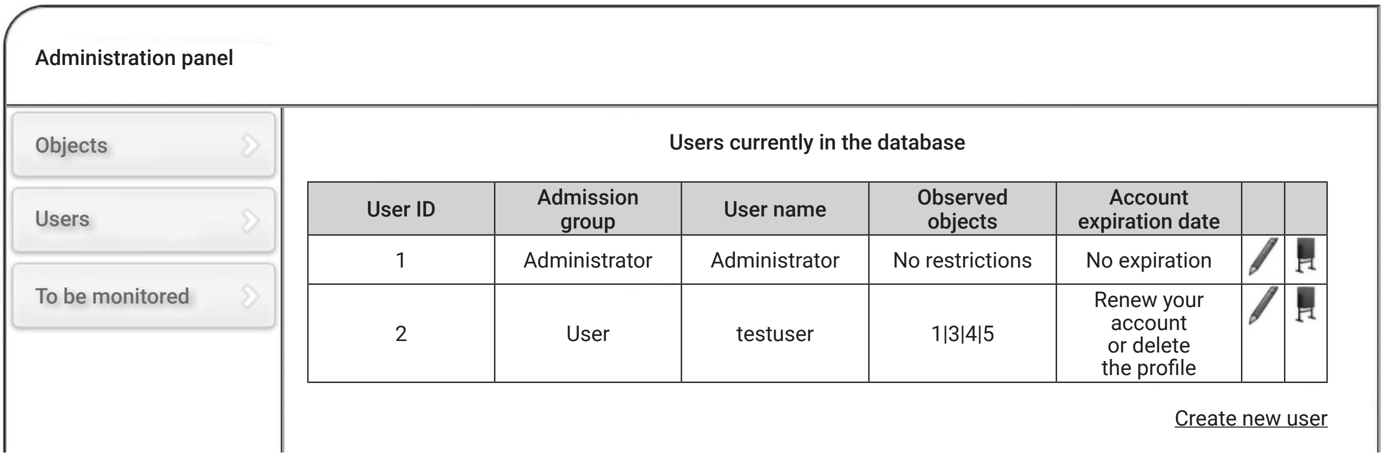
Discussion

Unlike various types of wired and autonomous temperature meters, the appliance has several distinctive advantages: the ability to carry out long-term automated remote monitoring of an object temperature without participation of the medical personnel (which excludes the impact of the human factor on



Akima spline Cubic spline Bézier curve

Figure 4. **Example of temperature curves and different spline fit**



User ID	Admission group	User name	Observed objects	Account expiration date		
1	Administrator	Administrator	No restrictions	No expiration		
2	User	testuser	1|3|4|5	Renew your account or delete the profile		

Figure 5. **Interface for setting system user profiles**

the registration of measurement results); the ability to simultaneously control the temperature of several patients (at least 100 simultaneously, the upper limit of the number of monitoring objects is determined by the capacity of the Wi-Fi network and the technical resources of the equipment).

The measuring and transmitting module is supplemented with a built-in external display, which allows for simultaneous visual monitoring of the current state of the patient temperature. The variant of its fixation on the forearm provides an unimpeded long-term presence of the measuring and transmitting module on the human body without limiting the motor functions of the hand and the need of holding the device.

Temperature monitoring is recommended for diseases of internal organs of various origins, as well as in pediatric practice, emergency care, anesthesiology and many other areas of medicine. Subfebrile condition is an increase of the body temperature from 37.0 to 37.9 °C, detected constantly or at any time of the day for several days or months. Subfebrile condition has an independent diagnostic value per se, which is especially important when it is the only symptom of a pathological process that has begun, while other objective signs are still absent.

Fever is one of the most common symptoms, for which patients see a specialist. Examples include persistent, laxative, debilitating, intermittent and other kinds of a fever. Each of these fever types characterizes some particular disease (based on the type of the temperature curve graph) [1]. In pediatric practice, thermometry is also among important indicators of a child's health. Body temperature in children is often associated with functional imperfection of their thermoregulation. Such imperfection is more pronounced in younger children [4].

The temperature curve reflects the disease course and the condition severity. It helps assessing therapy effectiveness, thereby predicting the patient's recovery time [5, 6].

Thermometry is one of the oldest diagnostic methods in gynecological practice, employing a test for measuring basal temperature, based on the progesterone hyperthermic effect, which directly affects the thermoregulation center [3].

Temperature monitoring is crucial in conditions of exploiting cryosurgical equipment, used in many medical fields, and various devices for implementation and studying of hypo- and hyperthermic effects on the human body.

Conclusion

Thus, the use of high-speed digital temperature sensors with a wireless data transmission channel in monitoring systems would expand diagnostic capabilities, and allow evaluating the effectiveness of therapy and preventive measures for many diseases.

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