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PROSPECTS FOR DESIGNING A PORTABLE SYSTEM FOR MONITORING OF THE PATIENT'S CONDITION WITH BRONCHIAL ASTHMA

Prof Muhammadu Sathik Raja [1], Deepan Raju.P [2],Bharath Kumar.R [3], Dinesh Kumar.M[4]
Assistant Professor[1], UG Scholar [2],[3],[4]
Department of Medical Electronics Engineering,
Sengunthar College of Engineering, Tiruchengode. Tamil Nadu, INDIA
[1],Scewsadik@gmail.com, [2],bharathkumarmee98@gmail.com, [3],deepanrajup@gmail.com,
[4],dineshkumarmee98@gmail.com

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Abstract— In this article the prospects and possibilities for creating an individual wearable system for monitoring the condition of a patient suffering from bronchial asthma and preventing attacks of the disease are discussed. As the basic method of determining the condition of the patient is considered the technique for determining the transmission coefficient of a certain frequency microwave signal through the chest. The proposed method is non-invasive and harmless and can be used for patients of all age groups.

Keywords— Bronchopulmonary diseases; Bronchial asthma; Diagnosis; Computerized diagnosis; Microwave band; Monitoring of the patient's condition; Telemetry; Telemedicine; Diagnostic equipment; Portable monitoring and diagnostic systems

INTRODUCTION

Bronchial asthma is one of the most severe bronchopulmonary diseases affecting people of all age groups, including young children. Currently, more than 300 million cases of bronchial asthma of varying severity have been detected worldwide [1]. In addition, there is a tendency to an increase in the number of patients with bronchial asthma, including young children. Therefore, the development of new methods and devices for the diagnosis of bronchial asthma, including inexpensive portable devices, is a very urgent task. Modern technologies are able to provide important tools for diagnosing a wide range of various diseases [2-4], including bronchial asthma [5]. At present, one can find a tendency to actively introduce modern technologies, in particular, in the development of modern low-cost portable devices for diagnosing or monitoring human condition [5, 6].

Such portable devices improve the quality of medical care and the availability of medical services due to the following advantages and opportunities:

- low cost of portable devices for diagnosing and monitoring the patient's condition and, therefore, their wide availability;
- absence of adverse effects on thepatient
- low cost and ease of implementation of the diagnostic device;
- providing a large amount of additional information about the course of the disease and the patient's condition without additional lengthy and expensive examinations;
- the possibility of using portable devices in addition to the main clinical examinations in order to make a more accurate diagnosis at earlier stages of thedisease;

- reduction of time spent under the direct supervision of a doctor due to the possibility of remote analysis of the patient's condition reducing the cost of medical services due to remote consultations;
- Provision of access of a greater number of patients to quality medical care in the absence of the possibility of direct access to large diagnostic centers.

This paper discusses the prospects for the development and implementation of a modern integrated portable system for diagnosing bronchial asthma based on non- invasive diagnostic methods.

METHODS AND APPROACHES

Currently, there are a large number of developments of portable systems that are capable of diagnosing or monitoring the condition of a patient suffering from bronchial asthma. However, the vast majority of such developments do not find widespread introduction into clinical practice, either due to the presence of deficiencies inherent in the methods used, or due to the complexity of the procedure for licensing medical equipment [7]. In [5], a review and analysis of a large number of studies aimed at the development and implementation of telemedicine systems for patients suffering from chronic bronchopulmonary diseases was carried out. The analysis of the results presented world are very interested in the implementation of integrated monitoring, information and emergency systems for the control of bronchopulmonary diseases. The simplest programs to control the incidence, involving the keeping of diaries of various kinds with the introduction of information about the symptoms and their causes. In more complex systems, there is the possibility of the patient's treatment by telephone or other means of communication in a specialized Call Center for advice on symptoms and necessary actions. The most complex systems involve the use of home systems, including portable systems, telemonitoring, and telemedicine.

Analysis of the effects obtained after the introduction of such programs of care about the health of the population, leads to the conclusion about their effectiveness.

In [8], the implementation of a portable system for people suffering from bronchopulmonary diseases is proposed, which is a combination of a patient activity sensor, a GPS tracker and an air pollution sensor. The sensors are installed in a compact case, which is fixed on the patient's body and transmits data to the central station, which can be implemented on the basis of a smartphone. Such a device is designed to inform the patient about the need to reduce activity in the case of determining a high degree of air pollution to prevent an attack of the disease. It is also proposed to form a map of air pollution by analyzing data obtained from a variety of similar devices. This will determine areas of excessive air pollution and inform patients about the need to refrain from visiting selected areas. The disadvantage of this system is that it is not able to determine the current state of health of the patient. However, the proposed device provides undoubtedly important information and is promising in the case of the integration of such sensors into a comprehensive patient monitoring system.

In the works [9-11] systems of individual control of the patient's condition are proposed by analyzing wheezing, recorded with the help of sensors - microphones. The audio signals from the sensors are processed in a specialized device placed on the patient's body, which then sends the data through the GSM network to the server of the medical organization for further analysis by the doctor and the formation of a medical report. The lack of such a system is in the complexity of signal processing, recorded in a noisy environment and lack of information about the location and severity of changes in the bronchopulmonary system, which is very important for making an accurate diagnosis and prescribing the list and dosage of medicines.

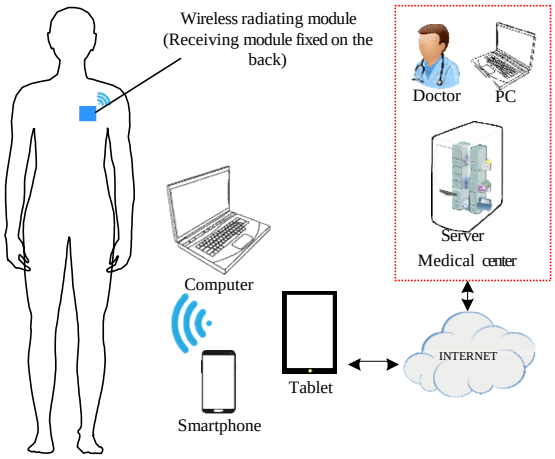
In the works [12, 13], the options for the implementation of compact spirographs, implemented either in the form of separate devices, or working in a set with a smartphone or tablet, are proposed. Despite the low accuracy compared with laboratory devices used in medical clinics, such devices due to their low cost can be very useful for periodic monitoring of their own condition. At the same time, compact dimensions and low cost of these devices contribute to their wide distribution. The lack of such compact spirographs in the absence of information about the localization of changes in the bronchopulmonary system, and the provision of only integrated information about the patient's condition. In addition, for the implementation of the diagnosis, it is necessary for the patient to perform certain respiratory maneuvers, which in some cases may be difficult or even impossible, for example, when examining young children. The use of low-power non-ionizing microwave radiation for diagnosing broncho- pulmonary diseases and monitoring the patient's condition on the basis of inexpensive portable devices used in the home or for continuous wear is promising. Previously, the authors presented a technique for non- invasive diagnosis of bronchial asthma [14], which is based on the phenomenon of the difference in the values of the microwave signal transmission coefficient through the healthy chest and through the chest with excessive sputum, which is a consequence of the disease. Experimental studies [15-18] demonstrate the ability to detect sputum accumulations in the patient's chest and generate information about the distribution of sputum in a graphical form. The advantages of this method are:

- low cost and ease of implementation of the diagnostic device;
- absence of adverse effects on thepatient;
- no need to perform breathing or other maneuvers during the examination process, which is a prerequisite for examining young children and seriously ill patients;
- The ability to implement portable low- cost diagnostic devices and monitor the patient's condition for home use.

These advantages allow us to consider the method of radiofrequency scanning as the basis for inexpensive modern portable devices for non-invasive diagnosis of bronchopulmonary diseases, including bronchial asthma, and monitoring the patient's condition of any ages, including young children.

STRUCTURE OF THE PORTABLE SYSTEM OF DIAGNOSTICS AND MONITORING OF THE STATE OF THE PATIENT

A generalized block diagram of a portable system for diagnosing bronchopulmonary diseases, including bronchial asthma, is shown in Figure 1. measurement results are transmitted via a wireless interface to a PC, tablet or smartphone and are recorded in an electronic diary or, for example, can be used to train a neural network. This will allow for the accumulation of data to adapt the program of processing results for a specific patient and more accurately monitor the change in its health. When the measurement results exceed the set limits, an alarm is generated, which is displayed as a message on the screen of the mobile device and can be sent to the email address of the medicalcenter.



The described individual system can be useful for continuous express monitoring of the condition of a person suffering from bronchial asthma during the day and warning him about the need to take medicine. In addition, it can be useful in medical institutions for monitoring the condition of a patient in hospital, and monitoring the effects of drugs. The task of the radiating module is to generate a microwave signal of a given frequency and power level and to minimize the side components of the output signal spectrum in order to ensure electromagnetic compatibility with other electronic devices operating in adjacent frequency bands. The block diagram of the radiating module is shown in Figure 2.

Fig. 2. Block diagram of the radiating module

A portable system for non-invasive diagnosis of bronchopulmonary diseases and continuous monitoring of the patient's condition is a combination of two compact modules — radiating and receiving, located on the side of the chest and back, respectively. The position of each module is fixed and does not change over time. The fixation point of the modules is determined based on the individual characteristics of the patient's body. The measurement of the transmission coefficient of the microwave signal is carried out discretely at specified time intervals, which will increase the time the device operates on battery power. The receiving module consists of a digital part, an analog microwave path that filters, amplifies and detects a microwave signal. The digital part of the receiving module performs analog-to-digital conversion of the detected signal and the transmission of measurement results to a computing device (smartphone) via a wireless interface.

The block diagram of the receiving module is shown in Figure 3. The results of the survey are accumulated in the form of the time dependence of the microwave signal transmission coefficient. Supplementing the results with information about the current health state of the patient and the symptoms of the disease will allow furthering formulating recommendations on the control of activity and the need to take medications. In the described portable system for diagnosing bronchial asthma, it is advisable to integrate additional sensors of patient's parameters, including a temperature sensor, a digital stethoscope, a breathing rate and a heartbeat meter, a system for recording wheezes in the patient's chest, which will allow collecting more complete information about the patient's condition.

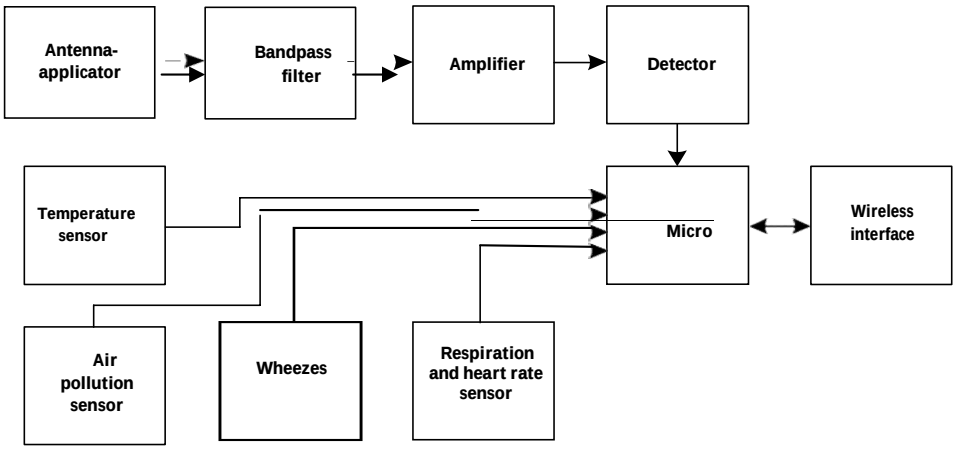


Fig. 3. Block diagram of the receiving and processing module

CONCLUSION

Thus, this paper discusses the prospects for introducing a portable system for diagnosing bronchopulmonary diseases, including bronchial asthma. A block diagram of the system is presented on the basis of a cheap patient status sensor in combination with a portable computing device - a smartphone, tablet, etc. Such a structure will significantly reduce the cost of the device, which will contribute to its wider distribution.

As the main method of state control, it is proposed to use the method of measuring the transmission coefficient of the microwave signal through the patient's chest. In this case, measurements are carried out at a single point, but for a long time, for example, when the device is continuously worn during the day.

The advantages of using microwave technologies allow us to apply the proposed structure to monitor the condition of patients of all age groups, including young children. The integration of additional sensors for the patient's vital activity and the state of the environment, together with the use of modern IT technologies, will enable the creation of a comprehensive system for monitoring the patient's condition and informing him of the necessary actions in a timely manner.

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