Development of a Program for Analytical Systems of Personal Diagnostics of People and Animals Based on the Piezoelectric Sensors Array

Tatiana Kuchmenko
Physical and Analytical Chemistry Department
Voronezh State University of Engineering Technologies
Voronezh, Russia
e-mail: tak1907@mail.ru

Ruslan Umarkhanov
Physical and Analytical Chemistry Department
Voronezh State University of Engineering Technologies
Voronezh, Russia
e-mail: rus_270487@mail.ru

Ivan Murakhovsky
Physical and Analytical Chemistry Department
Voronezh State University of Engineering Technologies
Voronezh, Russia
e-mail: ivan335522@mail.ru

Daria Kuchmenko
Endocrinology department
Voronezh Children's Clinical Hospital at the Voronezh State Medical University named after N.N. Burdenko
Voronezh, Russia
e-mail: darinochka_08@mail.ru

Abstract— **Modern methods of analytical chemistry are based on the measurement and processing of two- up to multidimensional signals. Multidimensional analytical signals include the responses of multisensory systems, such as artificial "nose, tongue, eyes". The purpose of this work is to develop software for personal diagnostic devices "electronic nose" with the possibility of clinical diagnosis of humans and animals by easily renewable selected biosamples. A program has been developed as a native Android application written in a high-level Java language, designed to interact with the electronic nose device. For the analysis of signals received from an array of 8 sensors, two algorithms have been developed. Analysis of the measurement is carried out on a complete data matrix which is generated when registering sensor signals over the skin of a person's hand or over a biosample. When processing the output data of the sensor, the most informative parameters about the health state of the body, individual organs and systems are obtained. Based on these parameters, visual smell traces are constructed by the sensor signals. The developed software personalizes the diagnosis of the health state of the human or animal using multisensory systems like electronic nose, and displays information in an understandable form to an untrained user. This makes it possible to use such devices for personal purposes, on small farms, therefore, to prevent the development of complex diseases, the death of livestock, and to improve the quality of life.**

Keywords- program; Java; non-invasive diagnostics; screening; sensors; metabolism; eHealth.

I. INTRODUCTION

Modern methods of analytical chemistry are based on the measurement and processing of two- up to multidimensional signals. Multidimensional analytical signals include the responses of multisensor systems, such as artificial "nose, tongue, eyes".

The purpose of this work is to develop software for personal diagnostic devices "electronic nose" with the possibility of clinical diagnosis of humans and animals by volatile metabolome of body or biosample [1].

Section 2 presents some state-of-the-art methods for processing and visualizing the signals from the multisensory systems. Section 3 describes the processing and visualizing features of sensor signals and the code of the proposed program. In Section 4, the conclusions and perspectives of the developed program application are provided.

II. STATE-OF-THE-ART METHODS

Currently available scientific developments of mobile applications for processing different information regarding health problems can be found in [2]-[4]. All such applications have basic diagnostic information, but there is no online connecting with a device based on sensors for non-invasive screening of health state. The final stage of our development will be a cloud service with artificial intelligence technology to provide complete information to customers about their health condition and tips for improving it.

III. DESCRIPTION OF PROGRAM

This program is written in a high-level Java language (Figure 1) as Android application, designed to interact with the electronic nose (e-nose) device and it is based on previous our works [5][6]. For the analysis of signals received from an array of 8 sensors, two algorithms have been developed. The first one allows getting the measurement results in a way that is understandable to any user. Initial processing of the measurement results is carried out by the maximum sensor responses, which forms a health state diagram (sphere), constructed based on the calculated data. Figure 1 shows a fragment of a software algorithm for assigning color to a sector in accordance with the values of sorption efficiency parameters calculated from the maximum sensor responses.

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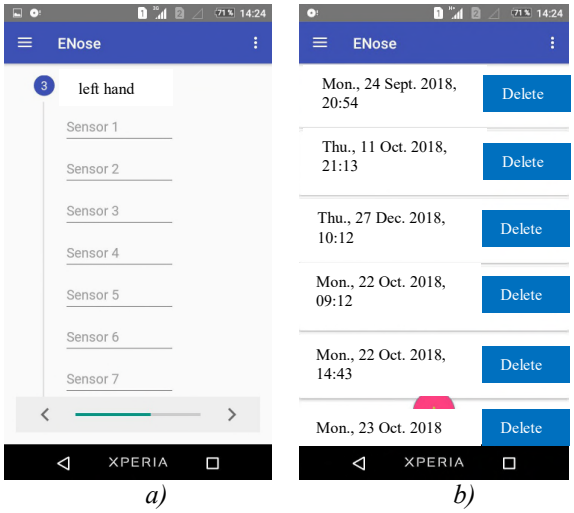
```
public class ResultAl_2 extends BaseResult {

  public ResultAl_2(double A, DataByMaxParcelable
inputData, Context context) {

   supei(A, inputData, context);

   setLegend("1_2");
}

//todo add "dry skin" If the skin is dry - color - red,
comments – Inflammation

 public void setResult(){

  if(getA() >=0.9&& getA() <= 1.14){

   if(getInputData(). isPractice()){
```

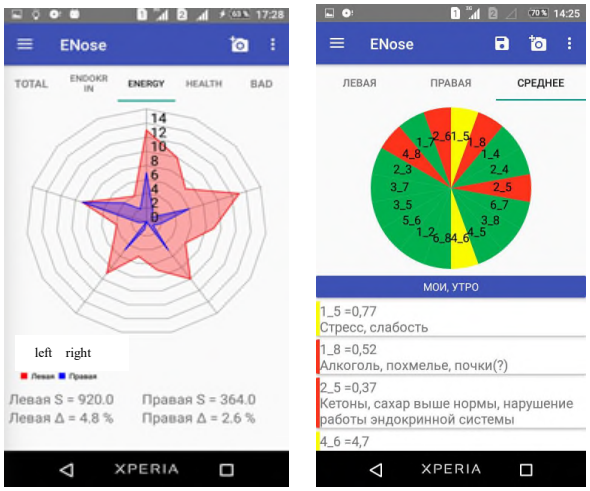
Figure 1. Fragment of a program about classes that work with the model data

The numerical boundaries of the reference values were determined experimentally for each sorption efficiency parameter. Depending on the interval in which the calculated parameters fall, certain comments about the health state of the body or about the volatile substances contained in the analyzed sample, are displayed. The program allows using the simplest responses of the sensor array in electronic nose to calculate a set of parameters that reflects the health state of both individual organs in the human body and the psycho-emotional sphere. Each calculation parameter is assigned numerical thresholds, text decoding, and color gamut, when the calculated value corresponds to certain semantic numerical ranges. It is possible to manually enter the values of the sensor signals (Figure 2a), as well as from the database of the e-nose for 2 measurements simultaneously with the possibility of averaging the calculated parameters. These 2 measurements may be the analysis results for one sample or for different ones.



a) *b)*

Figure 2. The dialog windows of program to input of sensor responses (*a*) and save the mesurements (*b*).



a) *b)*

Figure 3. Program dialog windows with text and graphical information as well as results of the comparison of two measurements for left and right forearm (*a*) and for average measurement with norm (*b*) – The green sector represents the normal health values for parameters included in the diapazon, while yellow and red represent deviations from norm.

The program provides processing as well as presentation of data for individual measurement and for averages as separate recordings in the dialog window of the program (Figure 2b). The decoding of the health state of the organism corresponding to the color scheme of each parameter is displayed on the screen together with a full set of calculated parameters in the form of a sphere, where each parameter corresponds to a separate sector (Figure 3 *b*). It is envisaged to save all data entered, calculated, and visualized (data measurement) to the database on a personal device.

A complete set of data is generated when registering sensor signals for 80 s of sorption and 120 s for desorption volatile substances excreted by the skin of a person's hand or by a biosample (for example, nasal mucus of cattle). When processing the output data of the sensor, the most informative parameters about the health state of the body, individual organs and systems are obtained. Based on these parameters, visual smell traces are constructed by the sensor signals.

The use of adaptive, high-level Java language provides high availability for users via Google Play Market. The proposed mobile application can describe more than 17 health conditions, including tiredness, stress, weakness, endocrine gland disorders, non-numeric level of glucose etc., due to connecting with portable e-nose based on piezoelectric sensors. Thus, the developed software surpasses modern world analogues in many parameters.

IV. CONCLUSION AND FUTURE WORK

The developed software personalizes the diagnosis of the health state of the human or animal using multisensory systems and displays the information in an understandable form to an untrained user. This makes it possible to use such devices for personal purposes, on small farms, therefore, to

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prevent the development of complex diseases, the death of livestock, and to improve the quality of life.

This approach to creation of software can be useful for processing and visualizing of output data from other sensor devices with 2-8 transducers.

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