«Voronezh State University of Engineering Technologies»

DEVELOPMENT OF A PROGRAM FOR ANALYTICAL SYSTEMS OF PERSONAL DIAGNOSTICS OF PEOPLE AND ANIMALS BASED ON THE PIEZOELECTRIC SENSORS ARRAY

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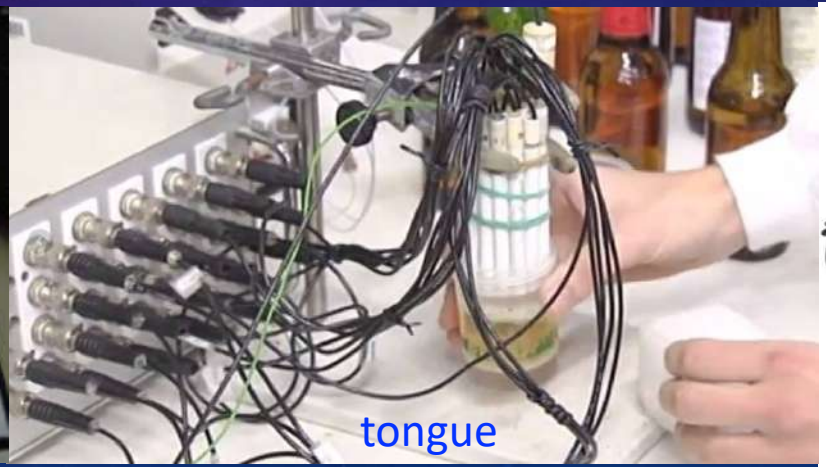
Ruslan Umarkhanov received his M.S. (2009) and Ph.D. (2013) degrees in analytical chemistry from Voronezh State University of Engineering Technologies (VSUET), Voronezh, Russian Federation. Currently he is assistant professor at the Department of Physical Chemistry of VSUET, the executive director of Sensorika-New Technologies LLC. Dr. Umarkhanov does research in nanomaterial-based gas sensors and artificial olfactory multisensory systems (E-nose) development. Dr. Umarkhanov has published 30 articles in highly rated and peer-reviewed journals, the author of 15 patents for inventions, 5 copyright certificates for software.

Ideological leader and head of research

Tatyana Kuchmenko received her M.S. (1989) and Ph.D. (2003) degrees in Analytical Chemistry from Voronezh State University, Voronezh, Russian Federation. From 2006 to present T. Kuchmenko is a head of the Department of Physical and Analytical Chemistry, FSBEI HE “VGUIT”, deputy director of Sensorika-New Technologies LLC company, from 2016 she is a professor of the Russian Academy of Sciences. T. Kuchmenko research in- terests involve development of methods for the analysis of mixtures of vapors and gases of an unstable composition, devices based on one or more diverse chemical sensors, methods of analysis with their use to determine the quality and safety of food products, raw ma- terials, non-food materials, environmental objects, biological samples for medical diag- nostics, indoor air, portable gas analyzers and systems with the intelligence of "electronic nose", personal health gadgets by body odor. Prof. Kuchmenko has published 2 mono- graphs, 13 study guides, more than 180 articles in highly rated and peer-reviewed pub- lications, 125 patents for inventions, 3 of them from other states (Ukraine and Yugoslavia), 8 copyright certificates for software.

Existing problems

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



MODERN METHODS

Currently, the scientific developments of mobile applications to process a variety of health information can be found.
All of these apps have basic diagnostic information, but there is no online connection to a sensor-based device for non-invasive health screening. The final stage of our development will be a cloud service with artificial intelligence technology, which will provide customers with complete information about their health and tips to improve it.

Program description

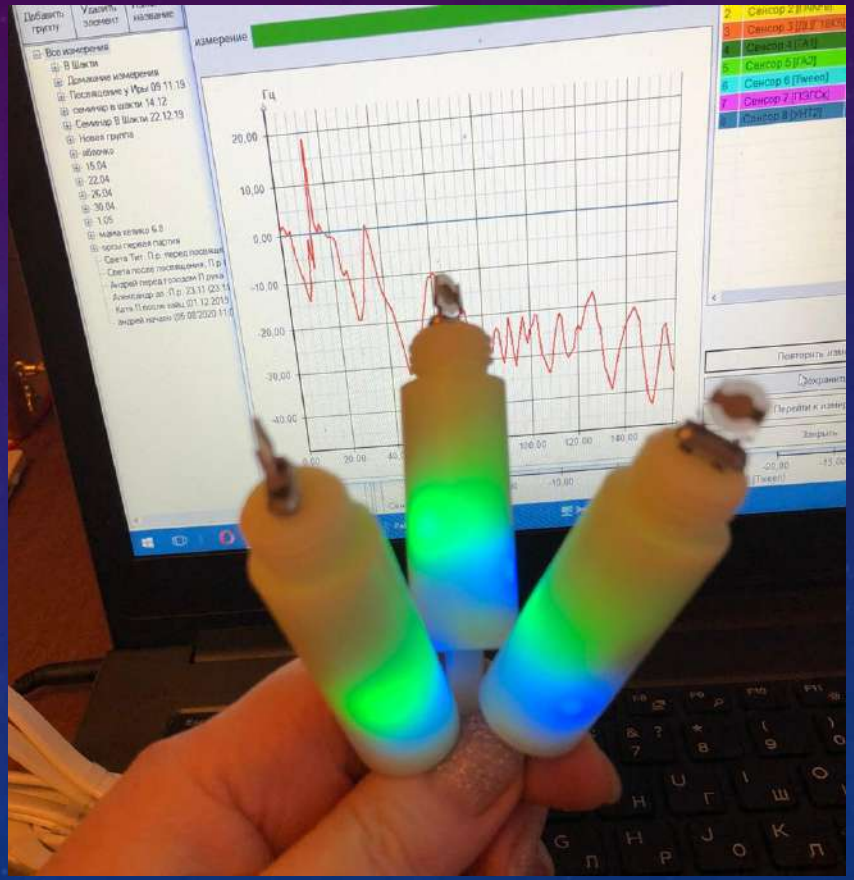
https://youtu.be/nkNZCnjiOWA?t=77

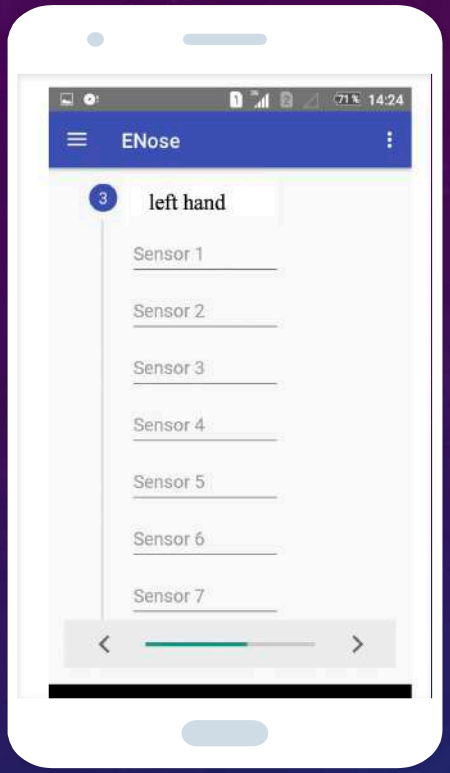
This program is written in a high-level Java language (Figure) as Android application, designed to interact with the electronic nose (e-nose) device and it is based on previous our works. For the analysis of signals received from an array of 8 sensors, two algorithms have been developed. The first one 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 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.

```
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()){
```

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.

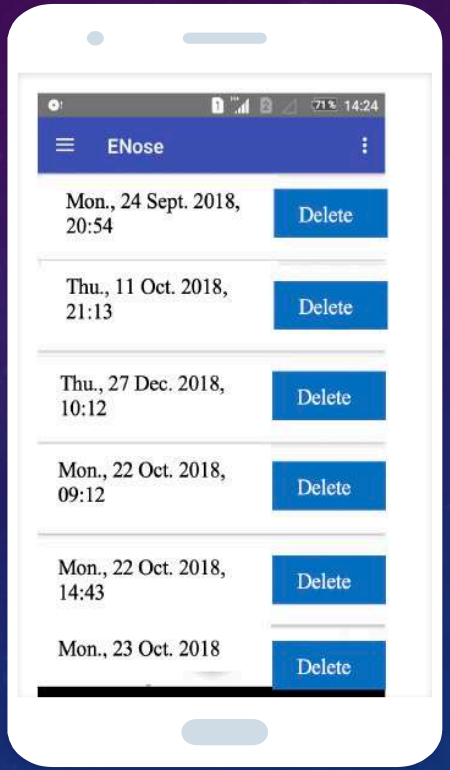




a)

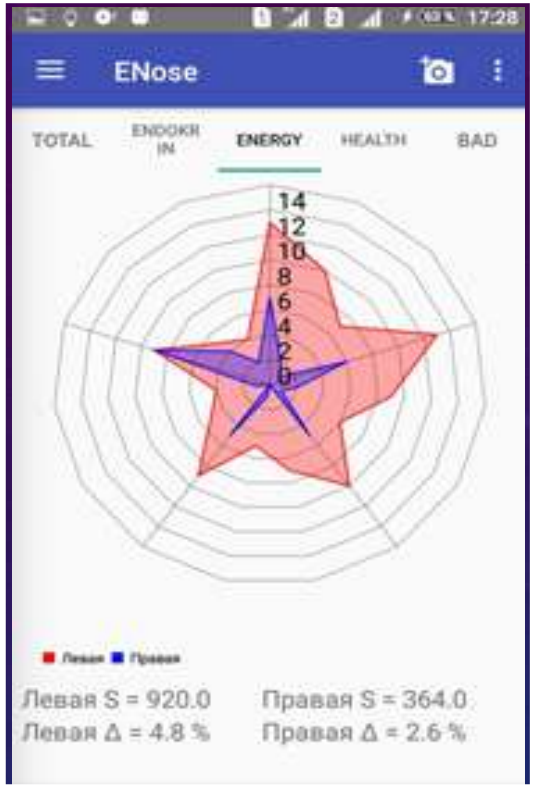
It is possible to manually enter the values of the sensor signals (Figure 2 a), as well as from the database of the e-nose for 2 measurements simultaneously with the possibility of averaging the calculated parameters. These 2 measurements may be the analysis results for one sample or for different ones.

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 2 b).



b)

THE DIALOG WINDOWS OF PROGRAM TO INPUT OF SENSOR RESPONSES (*A*) AND SAVE THE MESUREMENTS (*B*)



a)

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.

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 range, while yellow and red represent deviations from norm.

b)

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.

CONCLUSION

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 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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TEAM

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THANKS!

Any questions?

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