Diversity of Electronic Information Systems: "EcoIS" Monitoring System

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Abstract. Original classification of contemporary information systems was suggested. The system "EcoIS" for monitoring of chemical pollution of environment developed by the authors was described as example of specialized information systems.

The last decades have been characterized by intensive development of electronic information systems (ISs), and especially in medicine as a field that has always attracted particular attention and in which the latest scientific and technological achievements primarily were used. This explains the wide variety of electronic ISs types in medicine. The results of analysis of medical and biological ISs diversity based on about 300 contemporary publications is given below as well as their original classification. We have revealed that there are several basic types of ISs with databases (DBs) for **medicine** can be subdivided. We have ordered them according to the number of publications devoted to each type; the more publications are dedicated to a particular type of information system (IS), the more left it is in the list below. Therefore, in order of decreasing of number of publications, the types of ISs for medicine can be arranged in following order: medical ISs of general purpose > expert systems > electronic systems with images processing > electronic medical systems for documents processing > systems for scientific purposes > library medical systems > electronic medical training systems > medical databases (DBs)

By the same principles, the classification of ISs with DBs was done for the biological sciences and neurophysiology, as a branch that provides the results to both medicine and biology.

In **biology,** types of ISs can be arranged in the sequence: scientific ISs with DBs (also with teaching functions) > electronic library systems > electronic biological databases > electronic systems with images processing > expert systems in biology (including ones for scientific problems solution).

Respectively for **neurophysiology** the part of the items will be identical to the list for ISs designed for medical purposes, other one – with the list for biological ISs. As a result, the general classification sequence for neurophysiology is following: expert systems in neurophysiology (including ones for scientific problems solution) > electronic systems for images processing > electronic library systems in neurophysiology > DBs.

Comparing the three above-mentioned versions of contemporary ISs classification - in medicine, biology, neurophysiology, we would like to make following conclusions. 1. Medical ISs are characterized by the greatest diversity and proximity to the practice. 2. Electronic ISs in neurophysiology and biology are characterized by the greater proximity to scientific research. 3. The main focus of the developers is focused now on the development of: medical ISs of general purposes, electronic library systems, electronic systems for the work with documents, expert systems, IS for telecommunications and specialized ISs. 4. Respectively there are fewer publications about the following ISs: electronic systems with images processing, systems for scientific purposes, e-learning systems, and etc. Other ISs types were represented less, but the number and variety of IS for telecommunications and specialized ISs has increased significantly during the last 2020th year.
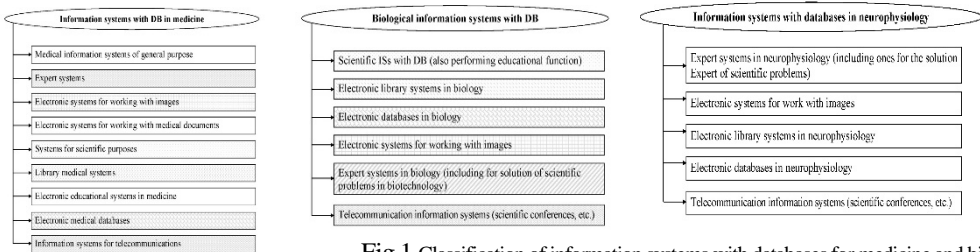

Fig.1 Classification of information systems with databases for medicine and biology

As example of specialized information systems we would like to represent original "EcoIS" system for monitoring of ecological state of environment (Figs. 2,3), created by Dr. Klyuchko O.M. The purpose of the work done was the development of new informational system for environment monitoring in wide time ranges using modern information and computer technologies, on the base of novel electronic information systems with databases. Some contemporary methods of environment protection, novel biotechnical and electronic information systems, as well as possibilities of their use for ecological monitoring of environment have been analyzed at the first stages of the work. During the work following methods were used: methods of comparative research of the samples of technical devices, imitation and program modeling, which were based on numerical own experimental results of the registration of changes in neuronal optical characteristics of as well as chemosensitive transmembrane electrical currents in mammalian brain neurons in voltage clamp mode and other methods. Used biophysical methods permitted to reveal and to identify substances, hazardous for living organisms and to make the first conclusions about their possible biological influence. In result the original system "EcoIS" has been developed for environment monitoring in broad time ranges (from the first moments of substances influence on single organism cells – to months and years after this influence on whole organism). This information system was coupled with detector groups, databases, expert subsystem and interfaces (Fig. 3); it was able to distinguish between certain types of chemicals at the input; to display their identification data and, if necessary, reports about their harmfulness. The first results of practical use of developed "EcoIS" were summarized; some of them were not possible to obtain with previously used devices and methods. "EcoIS" is information system with DBs for environment monitoring in three time intervals (from immediately examination of influenced neurons to long-term monitoring of the states of living organisms); it was suggested for the use in ecological scientific and academic practice, for environment protection. Detailed analysis and studying of peculiarities of biological objects and necessity to use of mathematic and other methods that was not used before become the basis for "EcoIS" development. The series of these works were continued with the elaboration of some other modifications of ISs with DBs, including DB of images, and electronic working places linked with DB for few specialties (ecologists, zoologists, etc).

Scientific novelties of the work done were following

- For the first time there was proposed technical system of environmental data collection and processing in which the biotechnical sensors (detectors) were connected with electrical signals with measuring devices, computer means; the system also combined algorithms of data processing and methods of eco-monitoring;

- for the first time there were developed methods and biotechnical devices –sensors (detectors), which allow measuring the influence of toxic substances much more accurately (on several orders of magnitude) in comparison with existing ones;

- for the first time a new type of methods for quantitative and qualitative analysis of organic substances (including pollutants) was invented as method, which allows to recognize approximate chemical structure of organic compounds in dependence of their influence on transmembrane electric currents, so in dependence on physiological effects they occurred. 4 patents of Ukraine were obtained for these methods. These works formed the scientific basis for the development of new technical systems for such chemicals detection and analysis.
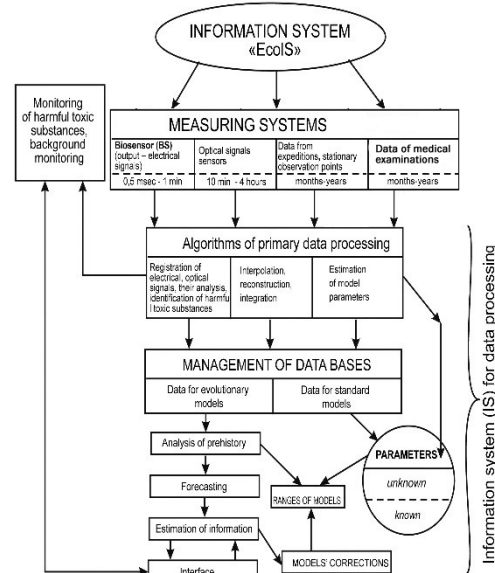

Fig.2 Specialized information system "EcoIS", developed for monitoring of chemicals in environment in broad time intervals

Practical values of obtained results

- We had developed a software and analytical system for ecological monitoring "EcoIS", which creates the possibility for conducting works on eco-monitoring on various objects of Ukraine (in the regions of industrial pollution, in areas with extreme conditions, where such monitoring is not possible due to the lack of funds or difficult access to these locations, and etc.).

- The inverse problem of determining organic chemical substances, the presence of pollutant molecules in the nature by their effects on the chemoactivated transmembrane electric (CTE-) currents was solved. The theoretical dependence of the damaging effect of ecotoxins on their chemical structure were found, such dependence might be the basis for the development of new technical expert systems for monitoring and analysis of chemicals in environment.

- We had elaborated some methods for detection of harmful substances in the nature; analytical expert system for some chemicals identification; electronic automatized workplaces (E-AWP or "ERM") and an improved analytical research complex for scientists of several specialties; such ERM became interfaces for communication between human and "EcoIS" or other systems from this family.

- Described results in their different parts and at different years were implemented at the National Aviation University, the International Center for Astronomical and Medical-Ecological Studies (ICAMED) of the National Academy of Sciences of Ukraine in the Caucasus (Russia, the Kabardino-Balkaria Republic, until 2009) and Uman State Pedagogical University. Obtained results also were used for monitoring of bioorganisms of Donbas – Striltzivsky Steppe Preserve (Ukraine), at Ukrainian Polissia, Ukrainian Carpathians and Elbrus region (Caucasus, Russia until 2009).

In process of the work following results were obtained and defended by **12 patents of Ukraine**:

1. The scientific basis has been developed and the newest technical system for eco-monitoring is being developed: it used a new type of the sensor groups as a technical means for the state of the environment monitoring. Accompanying laboratory, experimental methods and appropriate researches were done. The sensor model as part of a technical system for the diagnosis and testing of ecotoxins was elaborated; the corresponding software had been developed.

2. The numerical characteristics of interaction for all studied toxic substances were investigated, mathematical description of the processes of CTE-currents blocking by them in isolated neurons were performed. The general laws of the damaging action of toxic substances were established for organic substances – derivatives of phenol and indole with polyamine substituents of different length and branching. Due to the phenolic and/or indole fragments of the molecule of toxic substance, it interacts with the hydrophobic components of the membranes, due to the polyamine – it interacts with the glutamate receptor (Glu-R), providing the main mechanism of currents' blocking in our experiments. New methods of quantitative and qualitative analysis of studied toxic and harmful organic compounds were proposed.

3. The method to amplify 11.8 times the amplitudes of CTE-currents in neuronal membranes was elaborated; it permits to improve electric signals detection against noise backgrounds. Using of elaborated method the experimental recording of CTE-currents became more perfect, so, all electro-physiological recordings became more perfect too. 2 patents of Ukraine were obtained on these methods.

4. Algorithms, mathematical and programmatic approaches for the elaboration of databases for the developed "EcoIS" system, electronic automated workplaces (E-AWP), taking into account the features of bioobjects were proposed. Automated electronic work places were developed on the basis of the corresponding databases for use by scientists-biologists of several specialties (ecologists, neurotoxicologists, zoologists, etc.); they became interface to eco-monitoring system "EcoIS". E-AWP were elaborated on basis of network technologies. Developed E-AWPs are easy to use and quite satisfactorily meet the requirements of the relevant experts in experimental and theoretical data.
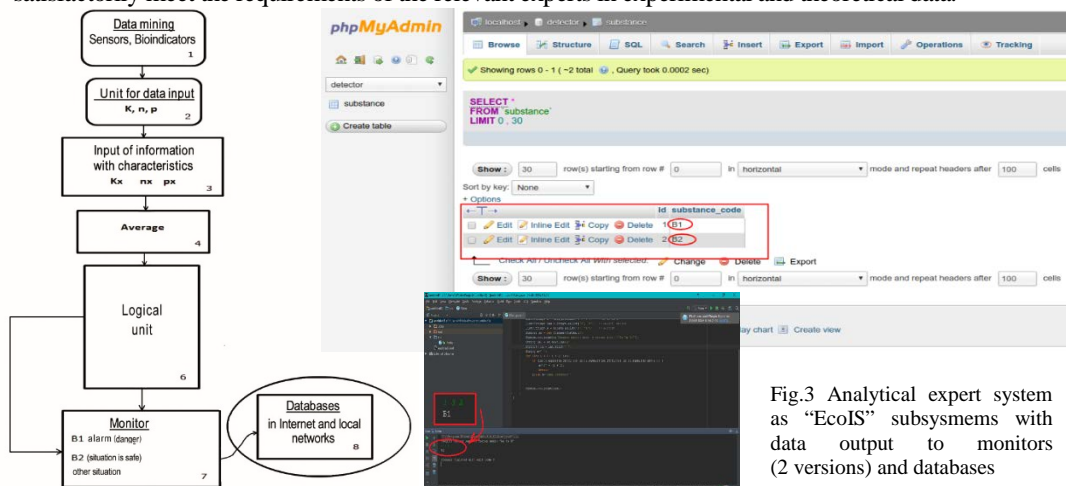

Fig.3 Analytical expert system as "EcoIS" subsysmems with data output to monitors (2 versions) and databases

Conclusions. Original classification of contemporary information systems was suggested. The system "EcoIS" for monitoring of chemical pollution of environment in three time intervals (from immediately examination to long-term monitoring) was developed and suggested for the use in ecological, scientific and academic practice, for environment protection. "EcoIS" is a networked technical information system based on distributed databases with information on bioindicators *Noctuidae (Lepidoptera)*; it was developed for the purpose of its use for professional monitoring of bioorganisms. This system included DB with results of ecomonitoring for some regions of Ukraine (Striltzivska Steppe Preserve (Lugansk region), Karpathian Mountains) and Russia (Prielbrussie, until 2009). It is possible to use this system for environmental protection. For this purpose it have to include also environmental monitoring equipment for the detection of polluting organic compounds, ecotoxins, to ensure environmental safety around industrial enterprises, including damaged as a result of man-caused and ecological disasters, in the areas of military actions, as well as accidents at chemical enterprises, other accident zones with industrial pollution.