Data Stream Mining & Processing

PROCEEDINGS of the

2018 IEEE Second International Conference on Data Stream Mining & Processing (DSMP)

IEEE Ukraine Section (Kharkiv)
SP/AP/C/EMC/COM
Societies Joint Chapter

IEEE Ukraine Section (West)
AP/ED/MTT/CPMT/SSC
Societies Joint Chapter

August 21–25, 2018

Lviv, Ukraine

Medical Data-Stream Mining in the Area of Electromagnetic Radiation and Low Temperature Influence on Biological Objects

Iryna Perova
Biomedical Engineering Department
Kharkiv National University of Radio Electronics
Kharkiv, Ukraine
rikywenok@gmail.com

Olena Litovchenko
Molecular Biology and Biotechnology Department
V. N. Karazin National University
Kharkiv, Ukraine
latyshkaelena@gmail.com

Yevgeniy Bodyanskiy
Artificial Intelligence Department
Kharkiv National University of Radio Electronics
Kharkiv, Ukraine
yevgeniy.bodyanskiy@nure.ua

Yelizaveta Brazhnykova
Biomedical Engineering Department
Kharkiv National University of Radio Electronics
Kharkiv, Ukraine
yelyzaveta.brazhnykova@nure.ua

Igor Zavgorodnii
Hygiene and Ecology No.2 Department
Kharkiv National Medical University
Kharkiv, Ukraine
zavnikua@gmail.com

Pavlo Mulesa
Cybernetics and Applied Mathematics Department
Uzhhorod National University
Uzhhorod, Ukraine
ppmulesa@gmail.com

***Abstract*—At this paper medical data stream mining in the area of influence by different fields (electromagnetic radiation and positive low temperature) on laboratory white rats is investigated. The most informative features in multidimensional time series using neural network based on Oja's neurons and the most informative physical field influence on biological objects (white rats) are detected.**

Keywords—Principal Component Analysis, Medical Data Stream Mining, Electromagnetic Radiation Influence

I. INTRODUCTION

The current state of the environment is represented by environmental factors of a different nature (physical, chemical, biological, social factors) that influence various biological objects, including human beings, both in everyday life and at work. Such a variety of factors predetermines their complex, mixed or combined, simultaneous or successive influence [1]. In such combinations of factors, biological systems form a whole complex of responses in organs and systems that depend on the strength, concentration, and time of action of these factors [2,3]. Ecological and biological researches should be aimed at determining the nature of these influences, the features of the development of mechanisms of biological effects at different levels of the body functioning, as well as determining the portion of the contribution made by each of the factors belonging to the complex of acting factors [1,4].

A fact that dimensionality of medical data sets is excess for solving of diagnostics tasks is one of the biggest problems in the area of Medical Data Mining [5-8]. This problem means containing of excess information in medical dataset that lead to complexity of analysis and interpretation of results. Data Reduction stage became a needed one for solving a common Data Mining tasks.

This stage permits to represent dataset in the compact and easy visualized form. Principal Component Analysis (PC-analysis) is one of most usable methods for solving data reduction tasks when dataset presents in the form of table "object-property".

When dataset is fed to processing in the form of data stream PC-analysis cannot be used and solving of data reduction task can be performed using neural network technologies. A neural network based on Oja's neuron [9] with its learning algorithm is the system that permits to perform data reduction sequentially in online mode.

II. ELECTROMAGNETIC RADIATION AND POSITIVE LOW TEMPERATURE INFLUENCE ON BIOLOGICAL OBJECTS

Scientists describe the present ecological situation in the world as «electromagnetic pollution of the environment» [10] in connection with the current spread of electromagnetic radiation (EMR) generated by different equipment. At present, the levels of exogenous electric and magnetic fields exceed significantly the natural background of the Earth and are an unfavorable factor, which influence on biological objects grows from year to year, acquiring a global character [11,12]. Sources of radiation can be found in all spheres of human activity, which are used in industry, medical practice, in the educational process, life and entertainment [13].

Recently, more and more researches are devoted to the problems of electromagnetic ecology. The world community recognizes that EMR is a significant environmental factor and has a high biological activity. Many international organizations are engaged in the development of this problem. Their research is aimed at studying the biological effect of EMR with subsequent development of the principles of regulation (methodology) in order to protect the population from the negative influence of EMR, as well as the substantiation of unified world standards for electromagnetic safety [3,11].

Numerous literature data indicate that EMR affects all organs and systems of the body: the blood system, cardiovascular, endocrine, immune, nervous and sexual systems with different biological activity (depressing, trigger or phase) in all frequency ranges [14,15].

However, despite a large number of studies, there is still no generally accepted theory of the effect of EMR on the body, its nature and the mechanisms of action on physiological systems. The reason for this may be attributed to the fact that EMR never acts as a monofactor. Other factors of a different nature that influence the body in combination with EMR are not excluded, which predetermined the urgency of the problem of medical and biological study of EMR influence on the human body in environmental conditions [1,14].

Another important environmental factor is the air temperature, which can provide comfortable or uncomfortable living conditions. The adverse effect of temperature on the body is possible under various circumstances, especially in winter, when the air temperature decreases [16].

Cold is a stressor for the body; in response, the activity of the most important regulatory systems is activated in order to maintain the temperature constant of the body. Hypothermia has a general effect on the body, causing biological reactions that manifest themselves as a complex of biochemical, pathophysiological, morphofunctional changes [17,18]. In response to irritation with cold, the body reveals a number of complex physiological reactions. It is proved that the corresponding reactions of the body to the effect of low temperature depend on the volume and duration of the effect of this factor [19].

Thus, the global spread of EMR, its combined simultaneous effect with a temperature factor can affect a person under different conditions. Proceeding from the above, it is necessary to study the influence of EMR in combination with a positive low temperature (PLT) on the body to determine the biological effects of the combined action: additivity, synergism, and antagonism. It is also necessary to determine the portion of the contribution made by each factor to the total effect, with subsequent development of criteria for evaluating the biological effect of EMR under conditions of cold stress followed by hygienic assessment and development of measures to prevent their impact.

With that end in view, we developed an original research model. An experimental study of the effect of physical factors on the animal organism is carried out: EMR and PLT, both in isolated action and in combined effect. The study was carried out under conditions of a subacute experiment during 30 days.

The Exposure Chamber equipment was created, which allowed to simulate both the influence of the required range of air temperature on laboratory animals and EMR parameters (Fig. 1). This model is protected by copyright [20].

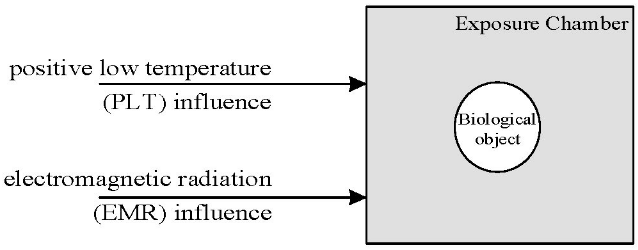

Fig. 1. Exposure chamber equipment

III. EXPERIMENT RESULTS PROCESSING

Laboratory white rats (males of the WAG line) were chosen as a biological object. The animals were distributed into 2 groups (N = 60). The research group consisted of 30 animals, which were divided into three groups: the first group of 10 animals was subjected to isolated EMR (operating frequency 70 kHz, electric voltage 600 V / m); the second group of 10 animals was influenced by the isolated effect of PLT in the range of + 4 °C ± 2 °C; the third group (10 animals) experienced combined effects of EMR and PLT at the same parameters as the groups of isolated action. The intact group of 30 animals was in comfortable conditions (+ 25 °C ± 2 °C) and served as a control in relation to groups 1, 2, and 3. Expositions were conducted during 4 hours, 5 times a week.

To reveal biological effects, the blood serum of animals was studied at the stage of 5, 15, 30 days in the dynamics of the experiment. The following biochemical parameters were determined in the blood serum: the content of diene conjugates (DC), malonic dialdehyde (MDA), SH-groups, ceruloplasmin, cholesterol, triglycerides, high density lipoprotein (HDL), low density lipoprotein (LDL), very low density lipoproteins (VLDL), urea, acid and alkaline phosphatase, chlorides, calcium, magnesium, phosphorus, total protein, glucose, catalase and superoxide dismutase activity; atherogenicity index (AI) was calculated. The indices were determined using commercial test systems with help of the biochemical analyzer "Labline-80" (Austria) in accordance with the instructions attached to them.

From mathematical point of view each object-white rat is described by multidimentional time series that contain information about the blood serum in 5, 15, 30 days:

$$X(k) = \{x_{il}(k)\},$$

where $k = 1,...,N,...$ – number of object-white rat in matrix (in our case $N = 60$), $i = 1,...,n$ – number of time series for each of white rat (in our case $n = 20$), $l = 1,...,q$ – number of time instants, that correspond to number of days ($q = 3$).

To present information in easy reception mode we have used neural network described in [9], [22]-[23] for each of time series. On Fig.2-Fig.4 position of each white rat in space of three principal components was presented. Intact group of white rats was marked by o-dots and research group – by *-dots. In each of groups different influence type was marked by different colors: black for the influence by the isolated effect of PLT, magenta for influence by isolated EMR, red for combined effects of EMR and PLT.

It is easy to see that proposed visualization presents that combined effects of EMR and PLT influence has significant correlation with the influence by the isolated effect of PLT on 5-th and 15-th days.

To determine this relation, it is easy to introduce a fuzzy clustering procedure between centers of groups with different influence type (one with PLT and one with EMR influence) and centers of group of combined effects [24].

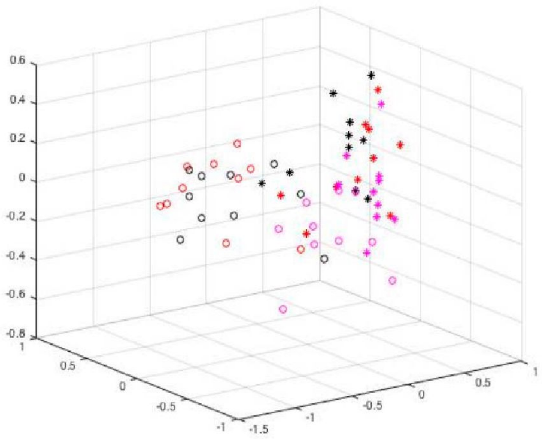

Fig. 2. PCA-visualization of each white rat on 5-th day of experiment

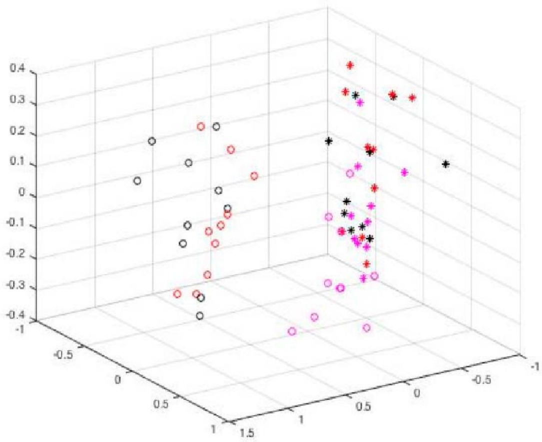

Fig. 3. PCA-visualization of each white rat on 15-th day of experiment

Previously, input multidimensional time series have to be centered, normalized and coded to interval $[-1;1]^{\{n\}}$.

For calculation of centers of each cluster is suitable to use arithmetical mean or median between all white rats of corresponding group in sequential mode:

$$c_{il}(k) = c_{il}(k-1) + \\ +\eta(k)\,\mathrm{sign}\left(x_{i+1,l}(k) - c_{il}(k-1)\right)$$

where $\eta_m(k)$ – learn rate parameter, that tuned accordingly with expression [25]

$$\eta(k) = r^{-1}(k), \quad r(k) = \alpha r(k-1) + 1, \quad 0 < \alpha \le 1.$$

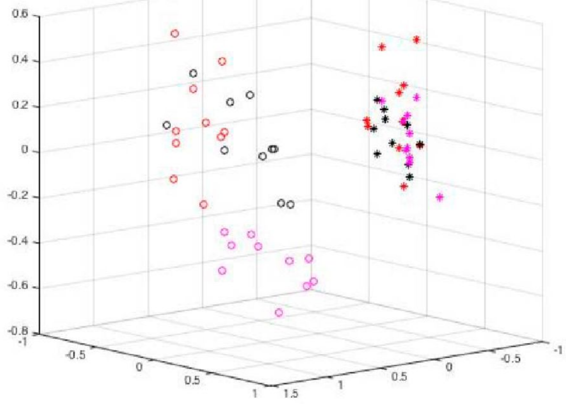

Fig. 4. PCA-visualization of each white rat on 30-th day of experiment

Distance in sense of Manhattan metrics between these centers is calculated in the form:

$$dist(c_{il}, c_{il}) = \sum_{i=1}^{n} \sum_{l=1}^{q} \left| c_{il} - c_{il} \right|$$

After that we can use a measure of distance to calculate what type of isolated influence contributes to combined one:

$$md = \frac{dist^{-1}}{\sum\left(dist^{-1}\right)}.$$

After calculation we obtain a result that the isolated effect of PLT has membership level $md = 0,67$ whereas the influence by isolated EMR $md = 0,33$.

At next step of our research it's needs to obtain information about most informative features. In the area of Medical Data Mining this problem is known as feature selection [18].

First eigenvector of covariance matrix should be calculated and first principal component vector should be formed. First principal component of coded multidimensional matrix $X(k) = \{x_{il}(k)\} \in R^{\{n\}}$ can be defined as:

$$\hat{y}^{(1)}\left(x_{il}(k)\right) = l_1 \cdot x_{il}(k)$$

where l_1 – first row of matrix L, eigenvector of covariance matrix, that corresponds to the biggest eigenvalue of this matrix.

At next step distances in the sense of Manhattan metrics between all features vectors and first principal component is calculated. A feature that has minimal distance

$$d\left(x_{il}(z), \hat{y}_{il}^{(1)}\right) = \sum_{i=1}^{N} \sum_{l=1}^{q} \left| x_{il}(k) - \hat{y}_{il}^{(1)} \right|$$

is chosen like the most informative one.

Then this feature-winner is excluded from original data matrix and system continues to process reduced matrix until all features will be turned over.

As a result the most informative features are: malonicdialdehyde (MDA), low density lipoprotein (LDL), urea, a superoxide dismutase, catalase.

IV. Conclusion

At this paper an isolated PLT and EMR influence and their combined effect on biological object – laboratory white rats was investigated. A contribution of isolated influence by PLT and EMR to combined influence was calculated. The most informative features in multidimensional time-series was determined.

References

[1] I. Belyaev, A. Dean, H. Eger, G. Hubmann, R. Jandrisovits, M. Kern, M. Kundi, H. Moshammer, P. Lercher, K. Müller, G. Oberfeld, P. Ohnsorge, P. Pelzmann, C. Scheingraber, and R. Thill "EUROPAEM EMF Guideline 2016 for the prevention, diagnosis and treatment of EMF-related health problems and illnesses," Rev Environ Health, vol. 31(3), pp. 363-397, Sep 1, 2016. doi: 10.1515/reveh-2016-0011.

[2] V. I. Nazarenko "To the problem of modulating influence of some physical factors on biological effect of EMF 50 Hz," Environment and Health, no. 4, pp. 38-43, 2009.

[3] European Commission, Directive 2013/35/ EU of the European Parliament and of the Council of 26 June 2013 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields) (20th individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC) and repealing Directive 2004/40/EC, 2013 (http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri= OJ:L:2013:179:0001:0021:EN:PDF)

[4] J. Kaszuba-Zwoińska, J. Gremba, B. Gałdzińska-Calik, K. Wójcik-Piotrowicz, P.J. Thor, "Electromagnetic field induced biological effects in humans". Przegl Lek, 2015, 72(11), pp.636-641.

[5] I. Perova, and Ye. Bodyanskiy, "Fast medical diagnostics using autoassociative neuro-fuzzy memory" International Journal of Computing, 16 (1), pp.34-40, 2017.

[6] I. Perova, and I. Pliss "Deep hybrid System of Computational Intelligence with Architecture Adaptation for Medical Fuzzy Diagnostics," I.J. Intelligent System and Applications, vol. 7, pp.12-21, 2017. DOI: 10.5815/ijisa.2017. 07.02

[7] I. Pliss, and I. Perova "Diagnostic Neuro-Fuzzy System and Its Learning in Medical Data Mining Tasks in Conditions of Uncertainty about Numbers of Attributes and Diagnoses," Automatic Control and Computer Sciences, vol. 51(6), pp.391-3982, 017. DOI: 10.3103/ S0146411617060062

[8] Ye. Bodyanskiy, I. Perova, O. Vynokurova, and I. Izonin "Adaptive Wavelet Diagnostic Neuro-Fuzzy System for Biomedical Tasks," 14th International Conference on Advanced Trends in Radioelectronics, Telecommunications and Computer Engineering (TCSET), Lviv-Slavske, Ukraine, pp.299-303, February 2018.

[9] E. Oja "Neural Network, principal components and subspaces," Int. J. of Neural Systems, vol. 1, pp. 61-68, 1989.

[10] G. Redlarski, B. Lewczuk, A. Żak et al. "The Influence of Electromagnetic Pollution on Living Organisms: Historical Trends and Forecasting Changes," BioMed Research International, 18 pages, 2015. doi:10.1155/2015/234098.

[11] P. Bodera, W. Stankiewicz, K. Zawada, B. Antkowiak, M. Paluch, J. Kieliszek, B. Kalicki, A. Bartosiński, and I. Wawer, "Changes in antioxidant capacity of blood due to mutual action of electromagnetic field (1800 MHz) and opioid drug (tramadol) in animal model of persistent inflammatory state," Pharmacol Rep, vol. 65(2), pp.421-428, 2013.

[12] S. Manzetti, and O. Johansson, "Global electromagnetic toxicity and frequency-induced diseases: theory and short overview," Pathophysiology, vol.19, iss.3, pp. 185–19, 12012.

[13] Yu. D. Gubernsky, M. E. Goshin, N. V. Kalinina, and I. M. Banin, "Hygienic aspects of electromagnetic pollution of modern dwelling," Hygiene and sanitation, no. 4. 2016. (https://cyberleninka.ru/article/n/ gigienicheskie-aspekty-elektromagnitnogo-zagryazneniya-sovremennogo-zhilischa).

[14] J. L. Phillips, N. P. Singh, and H. Lai, "Electromagnetic fields and DNA damage," Pathophysiology, vol 16, no. 2-3, pp. 79-88, 2009. DOI: 10.1016/j.pathophys.2008.11.005.

[15] S. Singh, and N. Kapoor "Health Implications of Electromagnetic Fields, Mechanisms of Action and Research Needs", Advances in Biology, pp.1-24, 2014.

[16] T. T. Qu, J. X. Deng, R. L. Li, Z. J. Cui, X. Q. Wang, L. Wang, and J. B. Deng "Stress injuries andautophagy in mouse hippocampus after chronic cold exposure," Neural Regen Res, vol. 12(3), pp.440-446, 2017. doi: 10.4103/1673-5374.202932.

[17] O. N. Kolosova, "Stabilization of homeostasis of rat body in cold influence with help of ethanol," Bulletin of experimental biology and medicine, vol. 160, no. 9, pp. 279-283, 2015.

[18] L. N. Maslov, S. Yu. Tsybulnikov, N. V. Naryzhnaya, V. V. Ivanov, and M. R. Tsybulnikova, "Chronic influence of cold –adaptation without stress," Pathological Physiology and Experimental Therapy, no. 1, pp. 28-31, 2016.

[19] P. Vargovic, M. Laukova, J. Ukropec, G. Manz, and R. Kvetnansky, "Prior Repeated Stress Attenuates Cold-Induced Immunomodulation Associated with "Browning" in MesentericFat of Rats," Cell MolNeurobiol, 38(1), pp.349-361, 2018. doi:10.1007/s10571-017-0531-z. Epub 2017 Aug 11.

[20] I. V. Zavgorodnii, V. V. Myasoyedov, V. O. Vekshin, R. O. Bachinsky, O. S. Teslenko, D. P. Pertsev, and G. L. Nikulin, Patent on useful model "Exposure Chamber" No. 83559, applicant and patent-owner Kharkiv National Medical University No. u201305791 dated 07.05.2013

[21] C. R. Rao "The use and interpretation of principal component analysis in applied research," Sankhay, A, vol. 26, no. 4, pp. 329-358, 1964.

[22] M. Okamoto "Optimality Principal Components Multivariate Analysis," Proc. 3 Int. Symp. Dayton, 1967.

[23] M. Okamoto, and M. Kanazawa, "Minimization of Eigenvalues of a matrix and optimality of principal components," Ann. Math. Statist., vol. 39, no. 3, pp. 1-20, 1968.

[24] O. Nelles, Nonlinear System Identification. Berlin: Springer, 2001.

[25] M. T. Vazan, Stochastic Approximation. Cambridge. Transactions in Mathematics and Mathematical Physics. Cambridge University Press, Cambridge, 1969.