UDC 004.02:556.01:616
DOI: 10.15587/2706-5448.2022.252297
Article type «Original research»

Olena Vysotska,
Konstantin Nosov,
Igor Knoevyi,
Andrii Porvan,
Liubov Rysovana,
Alexandr Dovnar,
Mikhail Babakov,
Marharyta Kalenichenko

IMAGE PROCESSING PROCEDURE FOR REMOTE RECORDING OF THE *GAMBUSIA SP.* INTRODUCED INTO A WATER FOR ANTI-MALARIA

The object of research is the procedure for processing digital images for remote registration of Gambusia sp., introduced into water bodies to combat malaria, which threatens not only the African region, but also other latitudes of the world. One of the most problematic areas of research is the elimination of the masking effect of a biological object under conditions of interference (for example, water turbidity) that make it difficult to recognize Gambusia sp. on digital images taken from aboard light drones.

In the course of the study, approaches were used that allow dividing a digital image into segments and subsegments, followed by determining the ratio of the colorimetric parameters of the RGB model of the bottom section. Dispersion and correlation analysis of mean values and mean square deviation values of the RGB model parameters were used. The standard deviation was considered as the degree of diversity of colorimetric parameters in the color of a biological object.

The proposed procedure made it possible to reveal a moderate negative correlation between the predominance of green and yellow-orange-red phytopigments in the dynamics of the Margalef model of phytocenosis succession in the places of introduction and habitation of Gambusia sp. This is due to the fact that the shielding of phytocenosis areas by Gambusia sp. is reflected in the nature of the relationship of the colorimetric parameters of the RGB model of the bottom area, namely, they affect the correlation between the average values of the parameters G/(R+G+B) and R/G or between the mean value and the standard deviation of the parameter G/(R+G+B). This makes it possible to use Gambusia sp. in regions affected by malaria, a wide range of light drones with remote photofixation of relatively low quality. The implementation of these possibilities will require much less material costs and a small number of personnel than underwater video filming and other known methods for studying the ichthyofauna of small water bodies in conditions of interference. It is about the registration of the results of the introduction of Gambusia sp. in such water bodies to fight malaria.

Keywords: *image processing procedure, remote image recording, malaria control, unmanned aerial vehicle.*

Received date: 12.11.2021
Accepted date: 28.12.2021
Published date: 17.01.2022

How to cite
Vysotska, O., Nosov, K., Hnoevyi, I., Porvan, A., Rysovana, L., Dovnar, A., Babakov, M., Kalenichenko, M. (2022). Image processing procedure for remote recording of the Gambusia sp. introduced into a water for anti-malaria. Technology Audit and Production Reserves, 1 (2 (63)), 14–18. doi: http://doi.org/10.15587/2706-5448.2022.252297

1. Introduction

Malaria is currently a major medical and biosecurity problem. According to the latest edition of the World Malaria Report (December 2021) [1], 241 million people were infected with malaria in 2020, up from 229 million in 2019. The same report showed that in 2020 627,000 people died from the infection, compared with 409,000 people who died from the disease in 2019.

The African Region continues to bear a disproportionate share of the global malaria burden. In 2019, 94 % of all malaria cases and deaths occurred in this region, and it is especially aggressive in sub-Saharan Africa, where more than 90 % of malaria cases in the world are recorded [2].

In 2019, approximately half of all malaria deaths worldwide occurred in six countries: Nigeria (23 %), Democratic Republic of the Congo (11 %), United Republic of Tanzania (5 %), Burkina Faso (4 %), Mozambique (4 %) and Niger (4 %). A geographical feature of these countries is a hot, humid climate and the presence of a fairly large number of small and small water bodies – habitats for the larvae of the malaria mosquito. The work [3] presents data that the temperature conditions of such reservoirs are very favorable for them. In turn, such spaces are often difficult to access.

Particularly susceptible to malaria are children under the age of five, who account for up to 67 % of all malaria deaths worldwide.

It should be noted that today the fight against malaria continues to be one of the urgent tasks. At the same time, the global malaria situation is not improving. In many countries with military and social conflicts or mass accumulation of refugees, it is even aggravated [1]. At the same time, aspects related to the physiology and ecology of blood-sucking insects (carriers of the causative agent of malaria) also play a significant role. And an important direction in the fight against malaria is the vaccination of the population in places of its distribution [4, 5].

The carriers of the causative agent of malaria are female mosquitoes of the genus Anopheles [6, 7]. The main habitats of their larvae in the regions of distribution of malaria are usually low-flowing shallow water bodies. Rice fields are a widespread artificial form of such reservoirs, the role of which in ensuring the food security of many states can hardly be overestimated. Let's note that it is about states in which the fight against malaria is an important factor in ensuring biosecurity. Based on almost a century of practical experience in sanitary and hygienic medicine, an effective means of combating malaria is now recognized as the introduction of fish into water bodies – representatives of the genus *Gambusia sp.*, eating mosquito larvae. In particular, in connection with this, the ecology and biology of these small fish is the subject of research, the results of which are presented in [8, 9]. The effect of malaria control will be achieved only when *Gambusia sp.* is introduced into large areas of often hard-to-reach (swamps, etc.) terrain.

To control this introduction under such conditions, modern science-intensive high-tech tools are needed. To study the ichthyofauna of small water bodies, for example, underwater video recording is becoming more and more popular [10]. But its use to control the introduction of *Gambusia sp.* faces problems of placing video equipment in reservoirs. And also with the problems of its protection in vast areas.

The problem of control over the processes of introduction in modern conditions can best be solved by remote (aerospace) methods. They are now becoming more widespread in the field of ecology and zoology [11, 12]. In large reservoirs and streams, it is promising, for example, to use them to study fish spawning [12, 13]. In this context, it is possible to talk about remote methods focused on the use of digital photography from the board of light drones – unmanned aerial vehicles (UAVs). The use of such methods may encounter problems due to the presence of a masking protective coloration (PC) in representatives of the genus *Gambusia*.

2. The object of research and its technological audit

The object of research is the procedure for processing digital images for remote registration of *Gambusia sp.*, introduced into water bodies to combat malaria. The procedure involves the subsequent analysis of the components of the RGB model and the quantitative evaluation of the $G/(R+G+B)$ and R/G ratios in the image. Based on the results of such an analysis, the ratios of green chlorophylls and yellow-orange-red pigments are determined in the phytocenosis.

One of the most problematic areas of research is the elimination of the masking effect of a biological object under conditions of interference (for example, water turbidity) that make it difficult to recognize *Gambusia sp.* on digital images taken from aboard light drones.

3. The aim and objectives of research

The aim of research is to develop a procedure for processing digital images of the water area for remote registration of *Gambusia sp.*

To achieve this aim, the following objectives will be solved:

1. Study of system parameters reflecting the ratio of diversity and evenness of color of phytocenoses in the places of introduction and habitat of *Gambusia sp.* and its protective coloration.

2. Selection of a set of system parameters that make it possible to statistically significantly distinguish areas of the water area with the presence and absence of *Gambusia sp.*

4. Research of existing solutions to the problem

Light UAVs are now increasingly used in field research in the field of ecology and biology [11, 12]. They also find their application in ichthyological studies [12, 13]. The use of UAV digital photography for remote recording of small, shallow-dwelling ichthyofauna will in many cases run into problems due to their protective coloration. Elimination of its masking effect will also be required with such use of UAVs for remote registration of *Gambusia sp.* The adaptive mechanisms of animal protective coloration (APC) are currently a popular subject of research in the field of fundamental biology [14].

The papers [15, 16] highlight the effects of climate change and artificial conditions of aquaculture on the coloration of fish. And the works [17, 18] are devoted to aspects of the coloration of representatives of different systematic groups of animals.

In the context of this work, of interest are the adaptive mechanisms of camouflage APC described in [19]. Specifically, the effect of dismemberment, in visual perception, of the silhouette of an animal. Achieving this effect involves a certain variety of color elements (spots, stripes) of the APC. This is required to ensure a high probability of their merging with the background at any point in the space of animal habitats. And taking into account the seasonal variability of the colorimetric parameters (CP) of these habitats, the same applies at any point in time.

At present, the work on mathematical modeling of the formation processes in the individual development of animal diversity of spots and stripes in the color picture of the life expectancy has received significant development [20, 21]. It is mainly about the genetic and biochemical aspects of these processes. It is initiated by the pioneering work [22] devoted to the mathematical modeling of Turing structures.

The paper [23] describes a new approach to animal unmasking based on digital image processing. This processing includes the designation of their segments with a conditional color corresponding to the CP diversity of the plant background and APC. These results were obtained as a result of using discrete models of dynamical systems (DMDS) developed at V. N. Karazin Kharkiv National University (Ukraine) [24]. In addition, in [20, 21],

ISSN 2664-9969

a formalized description of the regularities that determine the difference in the diversity of the background CPs of the habitat and APC was given.

In [25, 26], these differences are interpreted as related to the relationship of diversity and evenness in the CP of plant communities of habitats and APC. The regularities of the vegetation background CP dynamics described in [27] show a certain similarity with the so-called Margalef model of succession [28]. In a number of cases, these regularities, apparently, can also be extended to the dynamics of CPs of plant communities other than phytoplankton.

The work [29] shows, based on the patterns described in [25, 26], the procedure for processing digital images of coastal shallow sections of the river bottom. It makes it possible to identify changes in systemic CPs that serve as markers for the appearance of small, commensurate with *Gambusia sp.*, representatives of the ichthyofauna. It is about identification in conditions of interference by methods compatible with the use of light UAVs.

Thus, the results of the analysis allow to conclude that it is possible to develop existing methods for remote recording of biological objects under interference conditions, for example, *Gambusia sp.* using parameters reflecting the diversity and evenness of the APC and CP of the plant background. The specific form of these parameters can be determined by analyzing the RGB model of a digital photograph of bottom areas.

5. Methods of research

Systemic CPs reflecting the color relationships of diversity and evenness in the protective coloration of *Gambusia sp.* and in the color of aquatic phytocenoses in the places of its introduction and habitat were studied on the material of digital photos posted in the public domain. Using the Mathematic software package, by analyzing the components of the RGB model of these digital photos, the values of the primary colorimetric parameters (PCP) were found. The values of the following PCPs were determined, associated with the amount of green chlorophylls and yellow-orange-red pigments in the phytocenosis:

$$G/(R+G+B) \text{ and } R/G,$$

where G, R and B are the average number of green, red and blue elements per pixel, respectively.

The processing of digital images was carried out as part of a procedure that included the following operations:

– division of the image into segments;
– division of each segment into sub-segments;
– determination in each subsegment of the values of the parameters $G/(R+G+B)$ and R/G;
– determination for the set of sub-segments of each segment of the average values and the standard deviation of the parameters $G/(R+G+B)$ and R/G;
– determination for the set of segments of each image of the Spearman correlation values between the mean values and the values of the standard deviation of the parameters $G/(R+G+B)$ and R/G;
– analysis of the differences between the photos obtained in the variants with the presence and absence of *Gambusia sp.* in the frame, in the values of the Spearman correlations between the mean values and the standard deviation values of the parameters $G/(R+G+B)$ and R/G.

The standard deviation can be considered as a measure of the diversity of CP in the color of both the phytocenosis and *Gambusia sp.*

6. Research results

In accordance with the ideology of the Margalef model of succession [28], the average value of the R/G parameter can also be considered as a measure of the diversity of the pigment phytocenosis. But, from the point of view of the functioning of the protective coloration of fish, it is rather a measure of proximity to a certain optimum of the evenness of the red and green components of the APC.

Due to the predominance of chlorophyll green pigments in the phytocenosis, the average value of the $G/(R+G+B)$ parameter can also be considered as a measure of proximity to a certain optimum of the evenness of the red and green components of the APC.

In the dynamics of the Margalef model of succession [28] of relatively simple phytocenoses, a moderate negative correlation was revealed between the predominance of green and yellow-orange-red phytopigments. Such aquatic phytocenoses are present in the places of introduction and habitat of *Gambusia sp.*

Screening of areas of these phytocenoses by individuals of *Gambusia sp.* appearing in the frame finds its reflection in the nature of the relations of the considered CP.

These can be Spearman correlations between the mean values of the parameters $G/(R+G+B)$ and R/G, or between the mean value and the root mean square ratio of the parameter $G/(R+G+B)$.

Differences in these parameters in variants with the absence or presence of *Gambusia sp.* in the frame are presented in Table 1.

Table 1

Differences in selected parameters in variants with the absence or presence of *Gambusia sp.*

The variant with the absence of *Gambusia sp.*	There is an effect of statistically significant ($p<0.01$) negative Spearman correlations between the mean values of the $G/(R+G+B)$ and R/G parameters or between the mean value and the root mean square ratio of the $G/(R+G+B)$ parameter	Six cases of such photo registrations out of a total of six photo registrations
The variant with the presence of *Gambusia sp.*	There is no effect of statistically significant ($p<0.01$) negative Spearman correlations between the mean values of the $G/(R+G+B)$ and R/G parameters or between the mean value and the root mean square ratio of the $G/(R+G+B)$ parameter	Six cases of such photo registrations out of a total of six photo registrations

As can be seen from Table 1, in the absence of *Gambusia sp.* in six variants of the photo of the water area out of six, the effect of statistically significant ($p<0.01$) negative Spearman correlations of colorimetric parameters is observed. These are correlations between the mean values of the parameters $G/(R+G+B)$ and R/G, or between the mean value and the root mean square ratio of the parameter $G/(R+G+B)$. In the presence of *Gambusia sp.* this effect is not observed in any of the six variants (in all six, the effect is opposite in meaning).

Using the Fisher exact method (FEM) to assess the statistical significance of differences in the frequency of observations of qualitative effects, it is possible to determine the significance of the results of applying the proposed procedure for diagnosing the presence of *Gambusia sp*. in the water area as quite high ($p<0.05$).

In order to determine the direction of development of the presented imaging procedure for remote recording of *Gambusia sp*. introduced into water bodies for malaria control in the long term, a SWOT analysis was carried out.

7. SWOT analysis of research results

Strengths. The strengths of the presented procedure are:
– low cost and availability of technical equipment;
– remote registration of objects under study;
– does not require specialized training of personnel to work with UAVs;
– possibility of operational accounting of objects.

Weaknesses. The weaknesses of this procedure include:
– use of the procedure in small reservoirs;
– influence of the human factor when registering information in an automated mode.

Opportunities. Prospective possibilities of the presented procedure include:
– expanding the scope of the presented procedure;
– processing of digital images.

The conducted research can be useful for doctors, epidemiologists, infectious disease specialists in the fight against such a complex and rapidly spreading disease as malaria.

Threats. The main threats of the presented procedure include data loss.

8. Conclusions

1. The system parameters reflecting the ratios of diversity and evenness of the color of phytocenoses in the places of introduction and habitat of *Gambusia sp*. and its protective coloration. For this purpose, a procedure was developed to eliminate the masking effect of *Gambusia sp*. as a result of dividing a digital image into segments and subsegments, followed by determining the ratio of the colorimetric parameters of the RGB model of the bottom section obtained from a light UAV.

2. A set of system parameters has been selected, allowing statistically significant at the level of $p<0.05$ to distinguish water areas with the presence and absence of *Gambusia sp*. Based on Fisher's exact method, the average value and the standard deviation of the parameter $G/(R+G+B)$ of the RGB model of the bottom area were chosen as such markers, which make it possible to identify changes in systemic PCs.

This option can be considered as a research prototype, the use of which is expedient and promising for the development of automatic and automated systems for remote registration in conditions of interference of ichthyofauna objects. It is about remote registration of changes in systemic colorimetric parameters of *Gambusia sp*., which is introduced into water bodies to combat malaria.

In general terms, the obtained results represent a formalized description of some particular cases of manifestation of the known regularities in the functioning of the adaptive mechanisms of the protective coloration of animals.

References

1. *The World Malaria report 2021* (2021). World Health Organization, 322. Available at: https://www.who.int/publications/i/item/9789240040496
2. Ndwigah, S., Stergachis, A., Abuga, K., Mugo, H., Kibwage, I. (2018). The quality of anti-malarial medicines in Embu County, Kenya. *Malaria Journal, 17 (1)*. doi: http://doi.org/10.1186/s12936-018-2482-3
3. Huxley, P. J., Murray, K. A., Pawar, S., Cator, L. J. (2021). The effect of resource limitation on the temperature dependence of mosquito population fitness. *Proceedings of the Royal Society B: Biological Sciences, 288 (1949)*. doi: http://doi.org/10.1098/rspb.2020.3217
4. Butler, D. (2019). Promising malaria vaccine to be tested in first large field trial: The vaccine can confer up to 100 % protection and will be tested in 2,100 people on the west African island of Bioko. *Nature*. doi: http://doi.org/10.1038/d41586-019-01232-4
5. Vekemans, J., Schellenberg, D., Benns, S., O'Brien, K., Alonso, P. (2021). Meeting report: WHO consultation on malaria vaccine development, Geneva, 15–16 July 2019. *Vaccine, 39 (22)*, 2907–2916. doi: http://doi.org/10.1016/j.vaccine.2021.03.093
6. Bilgo, E., Lovett, B., St. Leger, R. J., Sanon, A., Dabiré, R. K., Diabaté, A. (2018). Native entomopathogenic Metarhizium spp. from Burkina Faso and their virulence against the malaria vector Anopheles coluzzii and non-target insects. *Parasites & Vectors, 11 (1)*. doi: http://doi.org/10.1186/s13071-018-2796-6
7. Girard, M., Martin, E., Vallon, L., Raquin, V., Bellet, C., Rozier, Y. et. al. (2021). Microorganisms Associated with Mosquito Oviposition Sites: Implications for Habitat Selection and Insect Life Histories. *Microorganisms, 9 (8)*, 1589. doi: http://doi.org/10.3390/microorganisms9081589
8. Hou, L., Chen, S., Chen, H., Ying, G., Chen, D., Liu, J. et. al. (2019). Rapid masculinization and effects on the liver of female western mosquitofish (*Gambusia affinis*) by norethindrone. *Chemosphere, 216*, 94–102. doi: http://doi.org/10.1016/j.chemosphere.2018.10.130
9. Huang, G.-Y., Liu, Y.-S., Liang, Y.-Q., Shi, W.-J., Yang, Y.-Y., Liu, S.-S. et. al. (2019). Endocrine disrupting effects in western mosquitofish Gambusia affinis in two rivers impacted by untreated rural domestic wastewaters. *Science of The Total Environment, 683*, 61–70. doi: http://doi.org/10.1016/j.scitotenv.2019.05.231
10. Asanov, A. Y. (2021). The method' features for assessing the number of fish in small reservoirs and watercourses using an underwater video camera. University Proceedings. Volga Region. *Natural Sciences, 3*, 85–97. doi: http://doi.org/10.21685/2307-9150-2021-3-8
11. Whitehead, K., Hugenholtz, C. H., Myshak, S., Brown, O., LeClair, A., Tamminga, A. et. al. (2014). Remote sensing of the environment with small unmanned aircraft systems (UASs), part 2: scientific and commercial applications. *Journal of Unmanned Vehicle Systems, 2 (3)*, 86–102. doi: http://doi.org/10.1139/juvs-2014-0007
12. Groves, P. A., Alcorn, B., Wiest, M. M., Maselko, J. M., Connor, W. P. (2017). Testing unmanned aircraft systems for salmon spawning surveys. *FACETS, 1 (1)*, 187–204. doi: http://doi.org/10.1139/facets-2016-0019
13. Kudo, H., Koshino, Y., Eto, A., Ichimura, M., Kaeriyama, M. (2012). Cost-effective accurate estimates of adult chum salmon, Oncorhynchus keta, abundance in a Japanese river using a radio-controlled helicopter. *Fisheries Research, 119-120*, 94–98. doi: http://doi.org/10.1016/j.fishres.2011.12.010
14. Endler, J. A., Mappes, J. (2017). The current and future state of animal coloration research. *Philosophical Transactions of the Royal Society B: Biological Sciences, 372 (1724)*. doi: http://doi.org/10.1098/rstb.2016.0352
15. Panayotova, I. N., Horth, L. (2018). Modeling the impact of climate change on a rare color morph in fish. *Ecological Modelling, 387*, 10–16. doi: http://doi.org/10.1016/j.ecolmodel.2018.08.008
16. Vissio, P. G., Darias, M. J., Di Yorio, M. P., Pérez Sirkin, D. I., Delgadin, T. H. (2021). Fish skin pigmentation in aquaculture: The influence of rearing conditions and its neuroendocrine regulation. *General and Comparative Endocrinology, 301*, 113662. doi: http://doi.org/10.1016/j.ygcen.2020.113662

ISSN 2664-9969

17. Valkonen, J. K., Vakkila, A., Pesari, S., Tuominen, L., Mappes, J. (2020). Protective coloration of European vipers throughout the predation sequence. *Animal Behaviour, 164,* 99–104. doi: http://doi.org/10.1016/j.anbehav.2020.04.005
18. Guillermo-Ferreira, R., Bispo, P. C., Appel, E., Kovalev, A., Gorb, S. N. (2019). Structural coloration predicts the outcome of male contests in the Amazonian damselfly *Chalcopteryx scintillans* (Odonata: Polythoridae). *Arthropod Structure & Development, 53,* 100884. doi: http://doi.org/10.1016/j.asd.2019.100884
19. Duarte, R. C., Flores, A. A. V., Stevens, M. (2017). Camouflage through colour change: mechanisms, adaptive value and ecological significance. *Philosophical Transactions of the Royal Society B: Biological Sciences, 372 (1724).* doi: http://doi.org/10.1098/rstb.2016.0342
20. Green, J. B. A. (2021). Computational biology: Turing's lessons in simplicity. *Biophysical Journal, 120 (19),* 4139–4141. doi: http://doi.org/10.1016/j.bpj.2021.08.041
21. Salis, P., Lorin, T., Laudet, V., Frédérich, B. (2019). Magic Traits in Magic Fish: Understanding Color Pattern Evolution Using Reef Fish. *Trends in Genetics, 35 (4),* 265–278. doi: http://doi.org/10.1016/j.tig.2019.01.006
22. Turing, A. M. (1952). The chemical basis of morphogenesis. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences, 237 (641),* 37–72. doi: http://doi.org/10.1098/rstb.1952.0012
23. Balym, Y., Vysotska, O., Pecherska, A., Bespalov, Y. (2017). Mathematical modeling of systemic colorometric parameters unmasking wild waterfowl. *Eastern-European Journal of Enterprise Technologies, 5 (2 (89)),* 12–18. doi: http://doi.org/10.15587/1729-4061.2017.110107
24. Zholtkevych, G. N., Bespalov, G. Y., Nosov, K. V., Abhishek, M. (2013). Discrete Modeling of Dynamics of Zooplankton Community at the Different Stages of an Antropogeneous Eutrophication. *Acta Biotheoretica, 61 (4),* 449–465. doi: http://doi.org/10.1007/s10441-013-9184-6
25. Bespalov, Y., Kabalyants, P., Zuev, S. (2021). *Relationships of diversity and evenness in adaptation strategies of the effect of protective coloration of animals.* doi: http://doi.org/10.1101/2021.05.06.441914
26. Bespalov, Y., Nosov, K., Levchenko, O., Grigoriev, O., Hnoievyi, I., Kabalyants, P. (2019). *Mathematical modeling of the protective coloration of animals with usage of parameters of diversity and evenness.* doi: http://doi.org/10.1101/822999
27. Bespalov, Y. G., Nosov, K. V., Kabalyants, P. S. (2017). *DIscrete Dynamical Model of Mechanisms Determining the Relations of Biodiversity and Stability at Different Levels of Organization of Living Matter.* doi: http://doi.org/10.1101/161687
28. Margalef, R. (1967). Concepts relative to the organization of plankton. *Oceanography and Marine Biology, 5,* 257–289.
29. Grigoriev, A. Ya., Levchenko, A. V., Ryabovol, A., Vysotska, O. V., Kalashnikova, V. I. (2021). Distance reading fishes in the water area by colorimetric parameters related to productivity and diversity of phytobentos. *Information systems and technologies in medicine (ISM–2021), 57.*

Olena Vysotska, *Doctor of Technical Sciences, Professor, Head of Department of Radio-Electronic and Biomedical Computer-Aided Means and Technologies, National Aerospace University «Kharkiv Aviation Institute», Kharkiv, Ukraine, ORCID: https://orcid.org/0000-0003-3723-9771*

Konstantin Nosov, *PhD, Associate Professor, Department of Theoretical and Applied Informatics, V. N. Karazin Kharkiv National University, Kharkiv, Ukraine, ORCID: https://orcid.org/0000-0003-4374-7502*

Igor Hnoevyi, *Doctor of Agricultural Sciences, Professor, Head of Department of Applied Biology, Aquatic Bioresources and Hunting them Professor A. S. Tertyshny State Biotechnological University, Kharkiv, Ukraine, ORCID: https://orcid.org/0000-0003-1350-6898*

✉***Andrii Porvan,*** *PhD, Associate Professor, Department of Radio-Electronic and Biomedical Computer-Aided Means and Technologies, National Aerospace University «Kharkiv Aviation Institute», Kharkiv, Ukraine, e-mail: a.porvan@khai.edu, ORCID: https://orcid.org/0000-0001-9727-0995*

Lyubov Rysovana, *PhD, Associate Professor, Department of Medical and Biological Physics and Medical Informatics, Kharkiv National Medical University, Kharkiv, Ukraine, ORCID: https://orcid.org/0000-0001-7937-4176*

Alexandr Dovnar, *PhD, Associate Professor, Department of Radio-Electronic and Biomedical Computer-Aided Means and Technologies, National Aerospace University «Kharkiv Aviation Institute», Kharkiv, Ukraine, ORCID: https://orcid.org/0000-0001-7171-0024*

Mikhail Babakov, *PhD, Professor, Department of Radio-Electronic and Biomedical Computer-Aided Means and Technologies, National Aerospace University «Kharkiv Aviation Institute», Kharkiv, Ukraine, ORCID: https://orcid.org/0000-0003-2270-196X*

Marharyta Kalenichenko, *Department of Radio-Electronic and Biomedical Computer-Aided Means and Technologies, National Aerospace University «Kharkiv Aviation Institute», Kharkiv, Ukraine, ORCID: https://orcid.org/0000-0003-4731-1060*

✉*Corresponding author*