

# Application of Industry 4.0 Technologies to Expand the Functionality of Water Bodies Interactive Maps

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**Abstract** — In the context of global problems of shortage of fresh and drinking water reserves, protection of natural reservoirs, issues of environmental monitoring, and digitization of quantitative and qualitative characteristics of water bodies in the territory of any region are urgent. One of the directions for solving this task is the use of innovative solutions based on Industry 4.0 technologies. The work presents means of expanding the functionality of interactive maps of water bodies based on the application of the bathymetry method and the use of 3D visualization, artificial intelligence, and the Internet of Things in the processing and interpretation of the received data. The obtained bathymetric data on digitized reservoirs will allow performing an analysis of underwater characteristics (depth, type of soil, level of pollution, including mechanical, density of vegetation, etc.) in the interests of assessing the state of the ecosystem, water volume, suitability for fishing or irrigation systems, etc. Experimental data were present on the example of water bodies of the Poltava region in Ukraine.

**Keywords** — *Interactive water maps, bathymetry, 3D-visualisation, Soft.Farm IS, Industry 4.0 technologies*

## I. INTRODUCTION

In modern conditions of climate change, urbanization and human industrial activity, as well as the impacts of agricultural production, alterations in land usage, military operations, and other factors, the issue of maintaining sufficient reserves of water resources to meet the needs of the population, animal husbandry, and agricultural production require access to fresh and clean drinking water is extremely pressing [1]. Almost 20 % of the world's population lives in regions facing a severe scarcity of clean drinking water.

Such trends require effective accounting and management of water resources at regional levels, heightened environmental awareness among the populace, careful attitude to natural resources, and the cultivation of ecological consciousness among citizens for environmental protection. In the European Union, the European Environmental Agency (EEA) creates updates and annually publishes databases on all water bodies in Europe and their compliance with European standards [2]. This process has also started in Ukraine. Considerable experience accumulated in all directions of such systematic work over the last decades and a lot of statistical data, indicators, etc. have been collected. For the effective use of existing databases and knowledge, bringing data to digital

forms of storage and processing, the application of innovative technologies and solutions within the context of the Industry 4.0 paradigm are relevant.

The Industry 4.0 technology framework attained a specific meaning and definition less than 10 years ago, but now truly revolutionary transformations, completely new approaches to production are being observed not only in the industry, but also in all areas of human activity without exception: agriculture (Agriculture 4.0), energy (Energy 4.0), economy (Economy 4.0), and other sectors [3-4]. Artificial intelligence (AI), the Internet of Things (IoT), robotics, and satellite monitoring are becoming effective additions to the prevailing systems and solutions. For example, in [5], the composition of a modern platform for managing production processes in the field of crop production was supported for the implementation of precision agriculture systems. Based on data analysis, it was shown how the use of such modules as GPS monitoring, satellite data in determining Normalized difference vegetation index (NDVI), weather monitoring and other innovative technical solutions can take production to a qualitatively distinct level and oversee all product indicators.

Water bodies of various types (rivers, lakes, ponds, reservoirs) make up a complex of water resources that are included in closed ecosystems, are a source for obtaining fish farming products, use in agricultural production to irrigate fields, maintain soil moisture, etc. Therefore, in each region, there are specialized regional departments of water bodies, the main function of which is system audit and monitoring of the effectiveness of water body utilization under lease conditions within a specific timeframe. To implement this functionality, the department of water objects solves the following tasks:

- Establishment of competitive avenues for water body utilization.
- Enhancement of operating conditions within the agro-industrial market.
- Regulation of water and property relationships within the agrarian economy.
- Creation of novel water bodies under state ownership.
- Support for the state's sustainable rural development policies.
- Provision of advisory assistance to enterprises and organizations concerning water-related matters [6].

It is also impossible to achieve effective activity in this area without IT technologies. An example is the creation and uses of special interactive maps of state-owned water bodies. The use of interactive electronic maps leads to dynamic visualization of the latest digital maps, which make it possible to create them with the help of monitors and special system programs. With the help of an electronic map, the efficiency and visual understanding of aggregate information about the object in digital form increases. The electronic card system designed in such a way that it has a multi-component model of reality. Electronic maps create with the help of digital cartography, which are also partly related to Geoinformation systems (GIS).

Despite the progressiveness of electronic maps of water bodies using, the combination with Industry 4.0 technologies allows supplementing with new indicators and data, create new layers. The purpose of this work is to apply innovative approaches to improve the means of creating and expanding the informativeness of maps of water bodies based on bathymetry methods.

There is an analysis of previous studies in the next section. Part III describes methods of data collection and visualization of water bodies on map. In Section IV, the authors suggest ways to improve the effectiveness of interactive maps and discuss the results. We determine the direction of future research in Section V and conclude our work in VI.

## II. STATE-OF-THE-ART

Today, bathymetry data is relevant for a specific region, but also for the entire state as a whole. They can be systematized by government services in order to generate forecasts at the national level [7].

Data may be collected from several sources, for example as described in [8]. It is most convenient for the end user to analyze information in a cartographic form or in the form of tables, graphs, charts. But in most cases, adapting such information to the needs of regional interests remains problematic, for example, due to the use of various GIS [9]. A way out of this situation may be the use of unified tools, for example, interactive maps based on public cloud services. At the same time, for the formation of bathymetry data of rivers and lakes today, the main source is artificial earth satellites for earth sensing [10], access to which is difficult.

As a consequence, to carry out bathymetry of water bodies such as rivers and lakes, you can use the tools that are discussed in [11]. It is possible to increase the efficiency of bathymetry due to the high resolution of the obtained data [12]. However, the most promising should be considered the use of modern machine learning technologies [13-16].

To automate the stage of transferring the received bathymetry data for subsequent processing, you can apply the technological basis, which is presented in [17].

Next, it is advisable to consider the option of implementing an interactive map of water bodies, the functionality of which can be adapted to the needs of specialized regional departments.

## III. METHODS FOR DATA COLLECTION AND VISUALIZATION OF WATER BODIES

Interactive maps of water bodies' use for a variety of purposes, such as providing information about water quality,

water levels, and water usage. They can also be used to visualize data related to water resources, such as precipitation, drought, and flood risk. These maps can be useful for environmental monitoring, resource management, and disaster response planning. They can also be used for educational purposes to help people learn about the importance of water resources and how to protect them.

The functionality of the electronic map is explained by the fact that it consists of a large number of layers. Such a complex of layers serves as the basis of typization for combining complex data. Processing of layers is performed using interactive and automatic tools. With the help of a system of filters, when a certain layer is found, a specialized system performs movement and writes this fragment to its own database. It is forbidden to view and process the layer in a mode. Thus, the electronic map system uses a multi-layered organization, which based on flexible management, which is combined to display a large amount of meaningful information. Presentation of electronic maps is possible in two modes: these are navigation modes, that is, real-time satellite images, or creation of a regular electronic atlas, that is, a regular map.

At the first stage of research, algorithms for data collection and visualization of water bodies were analyzed using an interactive map of water bodies on the example of the territory of the Poltava region. To achieve the set goal, it was necessary to solve the following tasks:

- Perform an analysis of software features.
- Define services for visualization of geographic objects.
- Development of the visualization algorithm for vector objects on the interactive map.
- Develop recommendations for the practical implementation of the proposed algorithm.

The MS Access Database Management System (DBMS) was utilized to create and manage the database. The import of primary data was handled from MS Excel spreadsheets. Two systems were considered as Geoinformation technology (GIS) software tools: Google Earth and Soft.Farm.

Google Earth encompasses functionalities such as satellite imagery and geographic information systems. In the global database of the Google Earth program, millions of satellite images of every part of the Earth are stored. With the help of these images, it is possible to view a certain area in real form. With the help of Google Earth tools, the following tasks can be performed at the user's need.

One of the alternative programs for creating geographic objects is Soft.Farm – a cloud-based IT solution for agricultural producers [5], allows the amalgamation of data into a unified format. The system uses the Google web service, which has a digital map of water bodies located in real time. Having use Soft.Farm's cadastral map, it was possible to easily view leased water plots on the electronic field map of any agricultural enterprise. Algorithmization of water bodies allows you to see the entire map and find discrepancies between the actual processed areas and the documentation. This site has a clear search for cadastral maps, which makes it possible to find a certain water object, and this information system has a large and informative database.

The web application has tools with which a clear object of the water table is developed, where the name of the cadastral

number, the area of the given object is recorded, after which the object is circled with lines. An example is shown in Fig. 1. In the picture, you can see the cadastral numbers and their status. If there is a green bar next to the cadastral number, it means that all information about the cadastral number is entered into the database and marked on the map. If there is a gray bar next to the cadastral number, then the information is missing. Information of cadastral plots is stored in KML format (Keyhole Markup Language), which makes it possible to use this map in other software.

At the Poltava State Agrarian University, users of the Soft.Farm information system are being trained within the framework of tripartite cooperation between the IT company, the university, and state authorities that need relevant specialists [18]. Comparative characteristics of the two systems are present in Table 1. During the processing of data on water bodies, appropriate algorithms for creating a database of water bodies were creating in both named systems (Table 1) based on data received from the Department of Agro-Industrial Development of the Poltava Region. As a result, images (Fig. 2 as example) of more than a thousand

water bodies and their passports were created, information was organized, and the economic effect of the use of information systems was calculated.

TABLE I. COMPARISON OF ADVANTAGES OF SYSTEMS FOR CREATING INTERACTIVE MAPS

System name	Key benefits of use
Google Earth	<ul style="list-style-type: none"> <li>- the program is free to use;</li> <li>- has the ability to view the area in more detail;</li> <li>- to work with the object, the possibility of using huge layers of data;</li> <li>- this program is updated using the Internet.;</li> <li>- allows you to view the terrain using 3D modeling;</li> <li>- the ability to preserve information using the HTML language;</li> <li>- the ability to select an object using colors.</li> </ul>
Soft.Farm	<ul style="list-style-type: none"> <li>- the program is free to use;</li> <li>- has the ability to view the area in more detail;</li> <li>- it is possible to use one layer for the object;</li> <li>- has the ability to add layers;</li> <li>- the update is created automatically via the Internet; installed electronic terrain meter.</li> </ul>



Fig. 1. An example of forming the contour of a water body in Soft.Farm with the indication of the cadastral number.

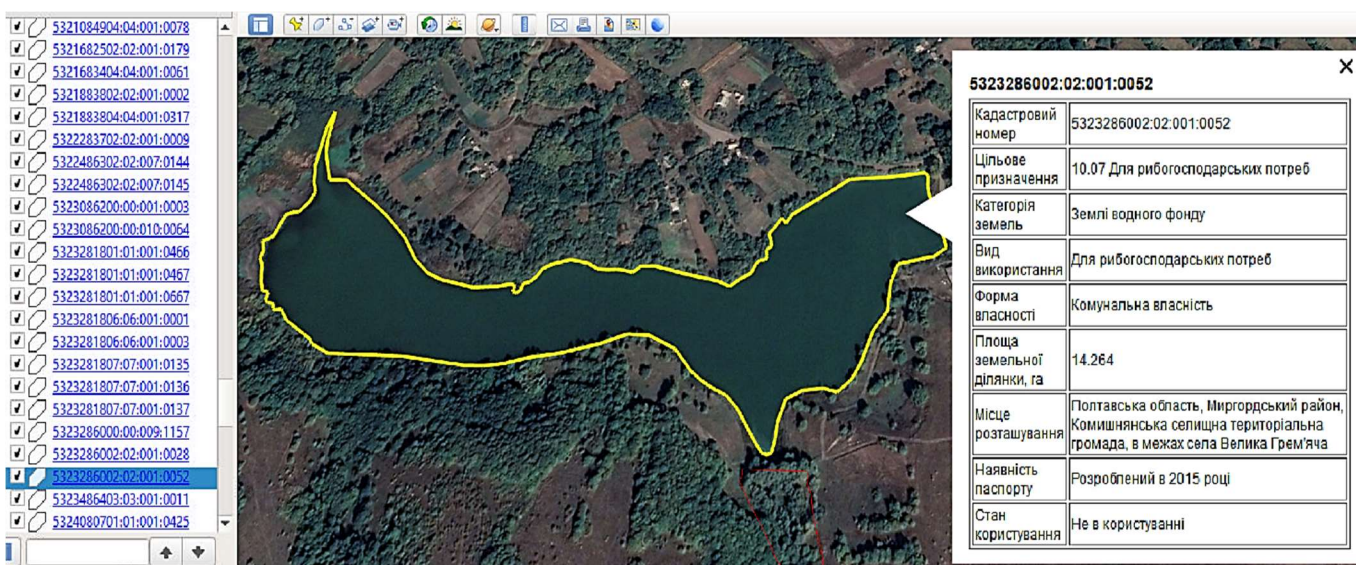


Fig. 2. An example of data description development in Google Earth.

#### IV. IMPROVING THE EFFECTIVENESS OF INTERACTIVE MAPS ON THE BASE OF BATHYMETRY AND RESULTS DISCUSSING

Nevertheless, despite the significant filling of the database of water objects, information about each specific subject remains insufficient. Interactive maps in their current state do not have data on the depth of the water body, relief and structure of the bottom, the presence of underwater vegetation, as well as the presence of various foreign objects and inclusions on the bottom of the water body. The last factor is relevant against the background of human economic activity or the conduct of hostilities.

In general, increasing the efficiency of using this interactive map is possible by expanding its capabilities through the generation of a 3D model of the water body [19]. This will make it possible to determine not only the volume of water, but also to assess the ecological condition of the object based on digitized data on the structure of the bottom and the layer of aquatic vegetation. In turn, on the basis of the accumulated statistical information about the conducted surveys, with the help of artificial intelligence tools, it is

possible to make forecasts, including long-term ones, of the corresponding characteristics, taking into account their seasonal fluctuations [20]. Solving this problem can be based on bathymetry [21]. To confirm the practical implementation of the proposed approach, experimental measurements for the bathymetry of one of the water bodies were carried out using an echo sounder [22]. Such devices are considered the most successful tool for measuring depth, determining the relief of the bottom and other underwater characteristics. For this, the Deeper PRO+ fishing echo sounder, which is equipped with a GPS sensor [23], was used. It can be controlled from a mobile device (Fig. 3) [24].

Thus, with the help of the device, you can create depth maps (color underwater contour maps) to obtain information about the density and uniformity of the bottom of the reservoir. To determine how hard or soft the bottom is displayed on the screen, several factors should be taken into account: the color and thickness of the bottom line and the presence of a second signal reflection. In addition, it is possible to estimate the intensity of the layers of aquatic vegetation on the trajectory of the echo sounder (Fig. 4).



Fig. 3. The interface of the mobile application for working with Deeper PRO: 1 – bottom scanning results; 2 – the current location of the sonar; 3 – bottom structure; 4 – vegetation layer.

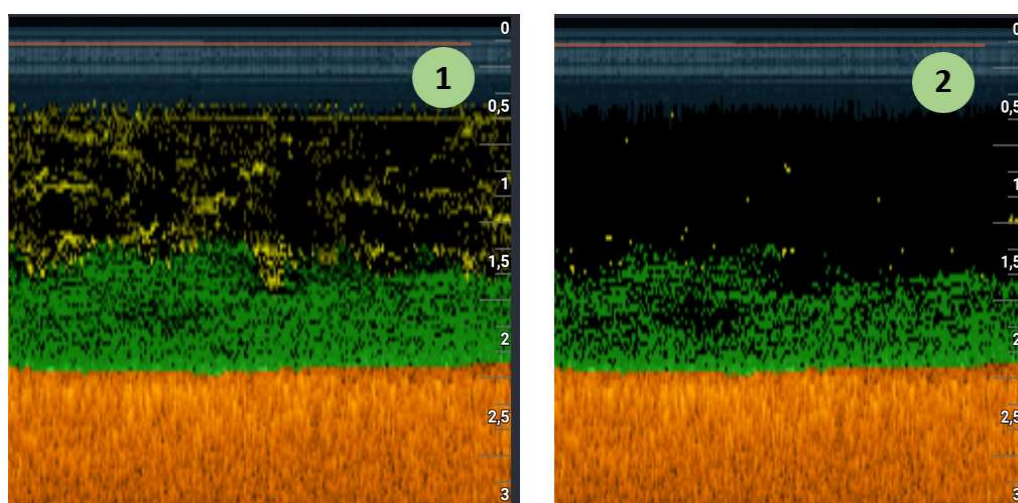


Fig. 4. Viewing the sonar track in several sensitivity modes: 1 – maximum; 2 – minimal.

It is important to pay attention to the color of the displayed objects (the frequency of the signal reflected from them will be different, so the echo sounder will show them in a different color than the bottom). Algae are displayed as vertical lines, and the signal from them will be intermittent. The echo sounder scans continuously, that is, the image on the screen will move all the time.

As a result, to track the dynamics of increasing or decreasing depth, you need to move the sonar smoothly. It is possible to obtain a more accurate image of the relief change and avoid "blind" areas during scanning by changing the signal frequency ("narrow beam" mode – 290 kHz). The existing functionality of the software allows you to download all the data obtained during each sonar scanning mission to the cloud storage "Deeper fish cloud" [25]. An example of viewing data from the cloud is shown in Fig. 5.

In addition, it is possible to export raw bathymetric map data in ".csv" format. This file will contain values such as latitude, longitude, depth, and timestamp. The timestamp will be displayed as the number of milliseconds since 00:00:00 Coordinated Universal Time (UTC) Thursday, January 1, 1970 (UNIX time). It is worth keeping in mind that the GPS sensor records latitude and longitude values approximately every second, and the echo sounder scans about 15 times per second.

Therefore, you can see the data value marked as "0" (the depth was recorded, but the coordinate is not). The available visual information allows the operator to analyze the attributes of the water body. However, in the presence of a large number of objects and/or their large area, it is advisable to automate this process based on AI. As a result, it's use is possible in the following independent areas:

- Image Processing – Deep learning algorithms can improve the quality and resolution of underwater images captured by sonar or other sensors.
- Object Recognition – AI can automatically recognize and classify objects in underwater images, such as coral reefs, shipwrecks or other structures.

- Data collection in difficult conditions (for example, turbid water) - AI algorithms can help in correcting and interpreting the data.
- Data fusion is the integration of different data sources (e.g. satellite, sonar, etc.) to create more accurate and detailed bathymetric maps.
- Optimize data collection for maximum efficiency and coverage of the entire site area when using AI in route planning for drones that collect bathymetric data.
- Data analysis and interpretation of large volumes of bathymetric data, identifying landform features or classifying seafloor types.
- Predicting changes in bathymetry as a result of phenomena such as erosion, sedimentary processes, or changes in water levels.

Thus, the received data can be further processed with the help of neural networks in order to determine the volume of water, form a digitized layer of vegetation and then superimpose it on a 3D map of the object, assess the condition of the bottom, form forecasts of changes in the attributes of the water body [26-29].

## V. PERSPECTIVES OF FURTHER RESEARCH

The use of the neural network apparatus in the processing of bathymetry data, echo sounder tracks containing information on the state of vegetation involves solving a number of tasks, which should include object detection, image segmentation, object classification, etc. Optimization of this approach is possible through the use of ready-made solutions, for example, for segmentation – Segment Anything Model (SAM) [30], object detection and classification – Ultralytics platform based on the current version of YOLOv8 [31].

As a result, it is advisable to focus further research on the synthesis of several deep learning models that will allow processing the received data, as well as processing time series in the interests of forecasting. Another, no less interesting, direction of development is the integrating VR/AR mechanisms, enhancing the visualization of geodata.

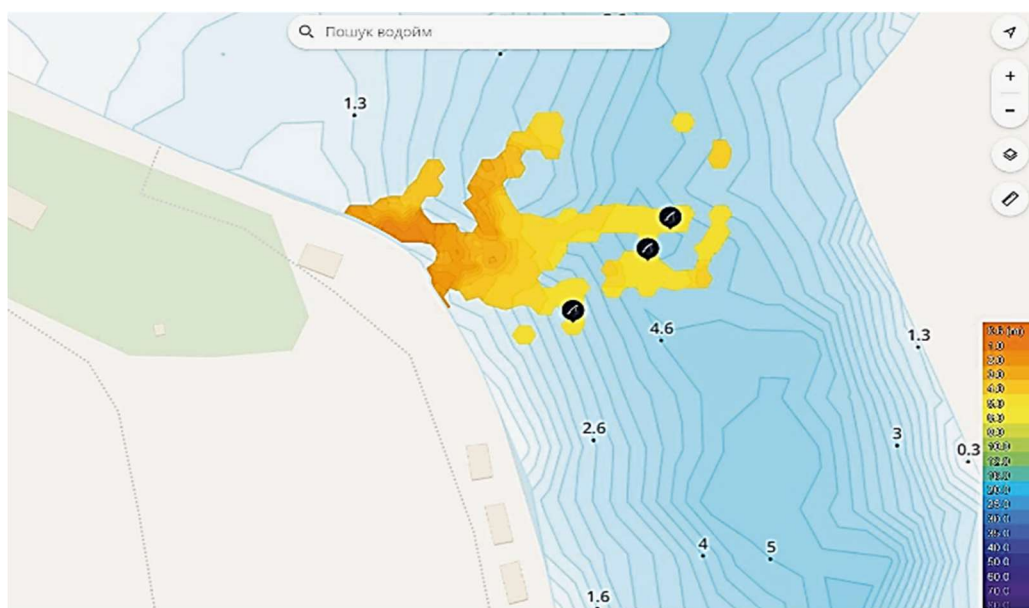


Fig. 5. A section of the image generated from cloud-stored data.

## VI. CONCLUSION

The paper considers the main approaches to enhancing the informativeness and visualization of geodata through interactive water body maps. As a basis, the use of bathymetry methods based on the results of experimental research was investigated. Conclusions were made regarding the expediency of using neural network tools in order to increase the automation and efficiency of the decision-making process based on forecasting the characteristics of water bodies. In general, the application of artificial intelligence in bathymetry can significantly improve the efficiency, accuracy and speed of data collection and analysis, which in turn contributes to a better understanding of underwater ecosystems and changes in them.

## REFERENCES

- [1] Water Framework Directive Quality Elements. Available online: <https://www.eea.europa.eu/data-and-maps/explore-interactive-maps/water-framework-directive-quality-elements> (Accessed at 20.08.2023).
- [2] European Environmental Agency. Official site. Available online: <https://www.eea.europa.eu/data-and-maps/explore-interactive-maps/state-of-bathing-waters-in-2022> (Accessed at 20.08.2023).
- [3] Queiroz, M.M.; Pereira, S.C.F.; Telles, R.; Machado, M.C. Industry 4.0 and digital supply chain capabilities: A framework for understanding digitalization challenges and opportunities. *Benchmarking* 2021, 28, 1761–1782.
- [4] Bongomin, O.; Yemane, A.; Kembabazi, B.; Malanda, C.; Chikonkolo Mwape, M.; Sheron Mpofo, N.; Tigalana, D. Industry 4.0 Disruption and Its Neologisms in Major Industrial Sectors: A State of the Art. *J. Eng.* 2020, 2020, 1–45.
- [5] O. Kopishynska, Y. Utkin, O. Galych, M. Marenych and I. Sliusar, “Main Aspects of the Creation of Managing Information System at the Implementation of Precision Farming”, *2020 IEEE 11th International Conference on Dependable Systems, Services and Technologies (DESSERT)*, Kyiv, Ukraine, 2020, pp. 404-410, DOI: 10.1109/DESSERT50317.2020.9125072.
- [6] PLAN of activities of the State Agency of Water Resources of Ukraine for the preparation of projects of regulatory acts for 2022. Available online: <https://davr.gov.ua/plan-diyalnosti-derzhavnogo-agentstva-vodnih-resursiv-ukraini-z-pidgotovki-proyektiv-regulyatornih-aktiv-na-2022-rik> (Accessed at 20.08.2023).
- [7] Miller-Corbett, Cynthia, 2016, Evaluating integration of inland bathymetry in the U.S. Geological Survey 3D Elevation Program, 2014: U.S. Geological Survey Open-File Report 2016–1126, 44 p., <http://dx.doi.org/10.3133/ofr20161126>.
- [8] Bathymetry of Lake Erie and Lake Saint Clair. Dataset Overview NCEI. Available online: <https://www.ncei.noaa.gov/metadata/geoportals/rest/metadata/item/gov.noaa.ngdc.mgg.dem:312/html>. (Accessed at 20.08.2023).
- [9] Geoinformation system for water cadastre. Available online: <https://magneticnemt.com/en/geoinformation-system-for-water-cadastre/> (Accessed at 24.08.2023).
- [10] I. Demir, K. Koperski, D. Lindenbaum, et al., “DeepGlobe 2018: A Challenge to Parse the Earth Through Satellite Images,” in *IEEE Conf. on Computer Vision and Pattern Recognition (CVPR) Workshops*, 2018. <https://doi.org/10.48550/arXiv.1805.06561>.
- [11] Li Z, Peng Z, Zhang Z, Chu Y, Xu C, Yao S, García-Fernández ÁF, Zhu X, Yue Y, Levers A, Zhang J and Ma J (2023) Exploring modern bathymetry: A comprehensive review of data acquisition devices, model accuracy, and interpolation techniques for enhanced underwater mapping. *Front. Mar. Sci.* 10:1178845. doi: 10.3389/fmars.2023.1178845.
- [12] Coggins LX and Ghadouani A (2019) High-Resolution Bathymetry Mapping of Water Bodies: Development and Implementation. *Front. Earth Sci.* 7:330. doi: 10.3389/feart.2019.00330.
- [13] Mandlbürger, G., Kölle, M., Nübel, H. et al. BathyNet: A Deep Neural Network for Water Depth Mapping from Multispectral Aerial Images. *PFG* 89, 71–89 (2021). <https://doi.org/10.1007/s41064-021-00142-3>.
- [14] “GLOBathy, the global lakes bathymetry dataset” by Bahram Khazaei, Laura K. Read, Matthew Casali, Kevin M. Sampson and David N. Yates, 3 February 2022, DOI: 10.1038/s41597-022-01132-9.
- [15] X. Liu, Y. Song, C. Shen “Bathymetry Inversion using a Deep-Learning-Based Surrogate for Shallow Water Equations Solvers”. <https://doi.org/10.48550/arXiv.2203.0282>.
- [16] K. Thor, M. Kaj Sand-Jensen, R. Selvan, “Predicting lake bathymetry from the topography of the surrounding terrain using deep learning”, *Limnology and Oceanography: Methods* published by Wiley Periodicals LLC on behalf of Association for the Sciences of Limnology and Oceanography. doi: 10.1002/lom3.10573.
- [17] O. Vasylenko, S. Ivchenko, and H. Snizhnoi, “Design of information and measurement systems within the Industry 4.0 paradigm.” *Radioelectronic and Computer Systems*, no. 1(105), pp. 45–54, 2023.
- [18] O. P. Kopishynska, Y. V. Utkin, S. V. Voloshko, I. I. Sliusar and O. G. Kartashova, “Algorithm of creating of an efficient cooperation between universities, business companies and agriculture enterprises during studying and implementation of information systems”, *2018 IEEE 9th International Conference on Dependable Systems, Services and Technologies (DESSERT)*, Kyiv, Ukraine, 2018, pp. 682-686, doi: 10.1109/DESSERT.2018.8409219.
- [19] X. Ma, V. Hegde, and L. Yolyan, “3D Deep Learning with Python”. Packt Publishing, 2022, 236 p.
- [20] S. Ravichandiran, “Deep Reinforcement Learning with Python”, 2nd Edition. Packt, 2020. 760 p.
- [21] J. Harper, “Bathymetry Concepts and Applications”. Callisto Reference, 2015. 160 p.
- [22] C. Jespersen, D. Docherty, J. Hallam, C. Albertsen, and L. Jakobsen, “Drone exploration of bat echolocation: A UAV-borne multimicrophone array to study bat echolocation”. *Ecology and Evolution*. 2022;12:e9577. URL: <https://doi.org/10.1002/ece3.9577>. (Accessed at 20.08.2023).
- [23] Deeper PRO+. Available online: <https://deeperonar.com/ru/ru/продукты/deeper-smart-sonar-plus-2> (Accessed at 20.08.2023).
- [24] Fish Deeper. Available online: <https://play.google.com/store/apps/details?id=eu.deeper.fishdeeper>.
- [25] Fish Deeper Web. Available online: <https://maps.fishdeeper.com/en-w> (Accessed at 20.08.2023).
- [26] V. Slyusar, M. Protsenko, A. Chernukha, V. Melkin, O. Petrova, M. Kravtsov, S. Velma, N. Kosenko, O. Sydorenko and M. Sobol, “Improving a neural network model for semantic segmentation of images of monitored objects in aerial photographs”, *Eastern-European Journal of Enterprise Technologies*, vol. 2, no. 6 (114), 2021, pp. 86-95. doi:10.15587/1729-4061.2021.248390.
- [27] Slyusar, V.; Sliusar, I.; Bihun, N.; Piliuhin, V. Segmentation of analogue meter readings using neural networks. In *Proceedings of the 11th International Workshop on Modern Machine Learning Technologies and Data Science (MOMLET&DS2022)*, Leiden, The Netherlands, 23–25 November 2022; pp. 165–175. Available online: [https://www.slyusar.kiev.ua/Slyusar\\_MoMLETDS\\_2022\\_6.pdf](https://www.slyusar.kiev.ua/Slyusar_MoMLETDS_2022_6.pdf) (Accessed at 20.08.2023).
- [28] V. Slyusar, I. Sliusar and P. Anatolii, “Improved PSP and U-Net Architectures for Forest Segmentation in Remote Sensing Pictures”, *2022 IEEE 2nd Ukrainian Microwave Week (UkrMW)*, Ukraine, 2022, pp. 614-618, doi: 10.1109/UkrMW58013.2022.10037105.
- [29] D. Filatov, G. Nabi and A. Yar, “Forest and Water Bodies Segmentation Through Satellite Images Using U-Net.” <https://doi.org/10.48550/arXiv.2207.11222>
- [30] Segment Anything Model (SAM). Available online: <https://github.com/facebookresearch/segment-anything>. (Accessed at 20.08.2023).
- [31] Ultralytics. Available online: <https://www.ultralytics.com>. (Accessed at 20.08.2023).