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INTELLIGENT NETWORKS: HOW ARTIFICIAL NEURONS ARE CHANGING THE APPROACH TO DATA PROCESSING AND PREDICTION

ІНТЕЛЕКТУАЛЬНІ МЕРЕЖІ: ЯК ШТУЧНІ НЕЙРОНИ ЗМІНЮЮТЬ ПІДХІД ДО ОБРОБКИ ДАНИХ ТА ПРОГНОЗУВАННЯ

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Abstract. *The development of computer technology has opened up new horizons for solving scientific and applied problems that require significant computing resources and processing large amounts of information. However, over time, problems have emerged for which traditional computing methods are no longer sufficient. For example, image recognition, prediction based on statistical data, or finding optimal parameters in complex systems require not only powerful hardware, but also innovative approaches to building algorithms. In such cases, classical programming turns out to be ineffective, since it requires the developer to have significant experience in the subject area, thorough processing of input data, and the creation of complex code that takes into account all possible options.*

In search of new solutions, experts turned to the principles of the functioning of the human brain, which is based on the transmission of electrical impulses between neurons. This natural mechanism has allowed the creation of artificial neural networks - a tool that simulates decision-making processes, is able to adapt, learn, and solve complex problems without the need for explicit programming. Due to their flexibility and power, neural networks have become the basis for creating intelligent systems in various industries - from IT to medicine and the food industry.

The modern environment also creates a need to work with Big Data - arrays of structured and unstructured data generated in enormous volumes. The use of artificial neural networks in working with Big Data allows not only to effectively process information, but also to find new knowledge, form forecasts and make decisions. This study considers the creation of an information system based on ANNs, which implements the learning function using a genetic algorithm, which allows you to adapt the network to the task at hand and increase its efficiency.

Розвиток комп'ютерних технологій відкрив нові горизонти для вирішення наукових і прикладних завдань, що потребують значних обчислювальних ресурсів та обробки великих обсягів інформації. Проте з часом з'явилися задачі, для яких традиційних методів обчислення вже недостатньо. Наприклад, розпізнавання зображень, передбачення на основі статистичних даних, або пошук оптимальних параметрів у складних системах потребують не лише потужного «заліза», а й інноваційних підходів до побудови алгоритмів. У таких випадках класичне програмування виявляється малоефективним, оскільки потребує значного досвіду розробника у предметній області, ґрунтовного опрацювання вхідних даних і створення складного коду, який враховує всі можливі варіанти.

Анотація. *У пошуках нових рішень фахівці звернулися до принципів функціонування людського мозку, в основі якого лежить передача електричних імпульсів між нейронами. Цей природний механізм дозволив створити штучні нейронні мережі — інструмент, який імітує процеси прийняття рішень, здатен адаптуватися, навчатися і вирішувати складні задачі без необхідності чіткого програмування. Завдяки гнучкості і потужності, нейронні мережі стали основою для створення інтелектуальних систем у різних галузях — від IT до медицини й харчової промисловості.*

Сучасне середовище також породжує потребу у роботі з Big Data — масивами структурованих і неструктурованих даних, що генеруються у колосальних обсягах. Застосування штучних нейронних мереж у роботі з Big Data дає змогу не лише ефективно обробляти інформацію, а й знаходити нові знання, формувати прогнози та приймати рішення. У цьому дослідженні розглядається створення інформаційної системи на основі ШНМ, яка реалізує функцію навчання за допомогою генетичного алгоритму, що дозволяє адаптувати мережу до поставленого завдання і підвищити її ефективність.

Key words: methodology, benchmarking, data, information, analysis, results processing, optimization, organization of scientific research

Ключові слова: методологія, бенчмаркінг, дані, інформація, аналіз, обробка результатів, оптимізація, організація наукових досліджень

Introduction

At the current level of development of computer technology, it has become possible to solve various scientific and research problems that require a lot of resources and processing a large amount of data and information for their solution. But with this, problems began to appear for the solution of which one computing power is not enough, for example, recognizing text written by a person and images of objects, forecasting based on some data, finding optimal parameters for the operation of various systems, etc. For such problems, the approach of conventional calculations, which uses an algorithm in, which has the ability to solve the problem with the full amount of specially processed and prepared information, will be very difficult and ineffective due to the fact that with this approach the programmer must have extensive experience in the subject area of the problem and have significant skills in working with information paradigms characteristic of this area, and the amount of code for will depend greatly on the amount of input information [7].

The development of information technology has contributed to the increase in computing power, which has made it possible to solve complex and resource-intensive tasks, but there is a wide range of tasks in which large resources are not a guarantee of solving the problem, for example, tasks such as pattern recognition or creating a forecast based on statistical data. Solving such problems by the classical method is very complicated due to the difficulty of creating such algorithms that would take into account all the nuances and possible combinations of events that can affect the result of scientific research.

Such tasks require a different approach, the method of solving such problems was borrowed from nature, namely from the structure of the brain, the principles of which allow solving problems of this kind with ease. The principle of brain thinking is based on the transmission of electrical impulses in interconnected neurons that form a neural network. Interestingly, to solve a specific task, the network can change and adapt, which allows solving many tasks using one concept. This led to the emergence of so-called artificial neural networks that imitate the way the biological brain makes decisions.

Artificial neural networks are a very powerful and flexible tool for solving various problems without direct programming, which allows you not to spend a lot of time searching for the best solution, as the network takes this search on itself during training. But to use artificial neural networks, you need to choose their type correctly and choose the activation function correctly, which will allow you to use neural networks more effectively, saving time and resources for solving the problem by improving the accuracy and speed of network training [6].

Artificial neural networks are used in various leading industries, including the IT industry, modern technological enterprises, in particular in the food industry. This proves that artificial neural networks are very flexible and, with a competent construction of a mathematical model of the problem, it makes it possible to solve it using statistical data collected during the analysis of the problem, which significantly improves the search for the optimal solution and allows you to realize the potential of the computing power of the hardware.

Identifying the dependencies of a mathematical model built to solve a problem that affect the structure of artificial neural networks will allow for more efficient construction of networks and models for them through competent design, which allows optimizing the operation of the entire system and reducing its complexity and cost.

Theoretical part

Human lives in a world where a huge amount of information surround. On January 2019, there are 4.388 billion active Internet users in the world. [1] This makes up almost 57% of the world's population. Almost everyone, in addition to consuming content, is also involved in its creation. Instagram, Facebook, YouTube, Tumblr, Twitter, Reddit, Pinterest are the largest social networks nowadays. From this list, the largest number of users is on Facebook - more than 2.5 billion users. All existing social networks are united by one of the most important things - the collection of personal data. This is no secret to anyone that they need transmitting their personal data. And they get not only social networks. Online stores, taxi calling apps, food delivery apps, bank apps, dating sites, maps - these are just some of the categories of companies that receive personal information about people. It is clear that in the first place they are necessary in order to identify a person. However, in addition to this, they collect other data that may be necessary for transfer to the third persons. Without your consent, no one will transmit this data to anyone, but when registering on various platforms, applications, social networks, etc. the person himself agrees to such actions, therefore, everything is honest [7].

Due to this, we move on to what Big Data is. In short, the concept of Big Data lies in the methods of processing a huge amount of data that can be structured and unstructured to obtain such results that a person will simply perceive.

The data that constitutes big data stores can come from sources that include web sites, social media, desktop and mobile apps, scientific experiments, and – increasingly – sensors and other devices in the internet of things (IoT). The concept of big data comes with a set of related components that enable organizations to put the data to practical use and solve a number of business problems. By applying analytics to big data, companies can see benefits such as increased sales, improved customer service, greater efficiency, and an overall boost in competitiveness. Data analytics involves examining data sets to gain insights or draw conclusions about what they contain, such as trends and predictions about future activity [2].

How do companies involved in this receive our, at first glance, not obvious, data? Likes, comments, reposts, marital status, place of work, participation in events, trips are just a small part of what can be used as a digital portrait of a person. How is this data used? All this data helps advertising agencies select content for the target audience, law enforcement agencies - find the criminal, banks - find people who can give out loans or mortgages [8].

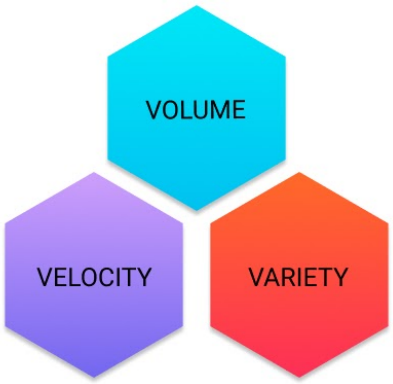

Fig. 1 - 3 V Big Data

Big Data has three key parameters or what they call 3V:

- ***Volume***. In social networks, for example, volume refers to the amount of data generated through websites, online applications, etc. Every day, users of social networks upload billions of posts, images, tweets, videos, etc.
- ***Variety***. By variety, we mean the speed at which data is generated. If we take the same social networks, every day 500 million tweets are published on Twitter, 3.5 billion search queries are performed on Google, 0.4 million hours of video are uploaded to YouTube [3]. Big Data helps companies receive huge incoming data stream and process it quickly.
- ***Velocity***. The diversity of big data applies to both structured and unstructured data. Unstructured data are voice messages, emails, audio recordings, etc. Velocity is the ability to categorize data into various categories.

Recently, new parameters have been added, such as veracity - reliability, viability - vitality, value - value, variability - variability, visualization - visualization.

All this is the reality of nowadays, that's why when all these are realities of our days, so when we read or process information, this is only a thousandth of all the information that comes from big data that will subsequently affect all areas of human life

Due to transition from natural to virtual communication, there are new technologies for presenting information, the perception of which depends on its presentation by modern multimedia. Visual perception plays an important role in everyday life, helping in learning and communicating with other people. Behind the most effective perception is a complex process of understanding the information obtained.

In 1998, Frank Tong, Ken Nakayama, Jay Thomas Vaughan, and Nancy Kanvisher concluded in an experiment that looking at two different images at the same time would have a binocular rivalry effect. When we see two different images in one place, one of them dominates and the other is suppressed. Dominance alternates at certain intervals. So, instead of seeing a combination of two pictures at once, we perceive them in turn as two competing for image dominance.

In 2011, Thomas Sanok and Noah Sulman conducted an experiment to study the effect of matching colors on memory. During the experiment, it was found that combinations of uniform colors are more harmonious and pleasant, while contrasting colors are more often associated with chaos and aggression, but they can be used to highlight or emphasize any information. Also, people tend to memorize palettes consisting of 3 colors than 4 or more, which is followed by the trend in the fashion of using 3 colors in the image [9].

Perception of media texts has the following stages:

- Psychophysiological state of perception of the physical sign of the text (word, color, spatial arrangement of the text, form of presentation of the material)
- The process of recognizing the text and its content (as familiar or unfamiliar), understanding its meaning in this context (distant or near).
- Active dialogic understanding of the meaning of the text (internal dispute or agreement with what is read)
- Understanding the meaning in a polylogical context.
- Selection of the main idea (meaning) of the content and its evaluation.

The visual perception of information includes the processes of seeing and reading. According to the theory of psychologist Richard Gregory, the processing and the process of forming an idea of the big picture consists of small

details. Building assumptions on what we see, we rely on expectations, beliefs, past knowledge and previous experience. Reading is a complex activity that involves both the process of perception and thought. At the very beginning of reading, understanding is not common, but only after perception, as the development and automation of reading skills, understanding begins to precede the process of perception, which manifests itself in the emergence of semantic assumptions, guessing meaning within individual words. Perception of the visual image is accompanied by the actualization of its auditory-motor image, without which it is impossible to recognize. Reading is accompanied by inner speech [10].

The same information can be understood by different people with different degrees of depth, which entails the existence of factors that affect the process of perception and understanding of texts. Such factors can be divided into the following groups: characteristics of the individual who acts as a subject of perception and understanding; parameters of the text and the reality that is reflected in this text; features of the situation in which the process of perception and understanding [5].

Practical part

With the transformation of access to information and its general globalization in information resources around the world, a period of rapid and significant growth in the number of users began. Information has become easy to find and download in a minimum of time on any of the available electronic gadgets.

Studying the benchmarking of reformed scientific institutions that have found their niche and are currently operating successfully, it is necessary to implement their successful ideas for work. Among the main areas of reform, the following can be distinguished: reorganization of space; availability of free and uninterrupted access to the Internet; creation of electronic services; uploading funds to digital format - easy and quick access to information. In parallel, media spaces are being created in libraries, where modern, interesting and exciting events for the local community are held, aimed at popularizing intellectuality, awareness, and education.

New formats for the work of modern scientific institutions can be: transformation into a "media library" with a significant part of the resource uploaded to the Internet; coworking – free space for work; holding art events: exhibitions, performances, creative meetings; organizing educational events: master classes, conferences, circles, lectures, round tables, etc.; creating an art cafe; opening a bookstore, etc.

Scientific research is becoming more diverse and potentially more competitive. Access to such publications makes original research freely available on the network, but when opening data, it is necessary to choose only those resources that ensure compliance with copyright and licensing rights.

Many systems and resources formulate the principles of open data, one of which is OCSDNet. The key principles include:

Principle 1. Includes common knowledge, when each person has the means to decide how to manage their knowledge and manage it to meet their needs.

Principle 2. It recognizes cognitive justice, the need for diverse understandings of knowledge for coexistence in the scientific community.

Principle 3. Programs located in Open Software

Principle 4. Upholds the right of every person to research and ensures various forms of participation at all stages of the research process.

Principle 5. Promoting fair cooperation between scientists and social actors.

Principle 6. Stimulates an inclusive infrastructure that enables success and the use of available open source technologies.

Principle 7. Using knowledge as a path to sustainable development, equipping every individual to improve the well-being of our society and the planet.

All these principles of open science are the basis for the formation of institutional repositories. Institutional repositories are an electronic archive for long-term storage, accumulation and ensuring long-term and reliable open access to the results of scientific research conducted at the institution.

The process of synergies of working with big open scientific data to the processes of implementing neural networks is logical.

In the modern information space, where terabytes of data are generated every day, there is a need not only to process these volumes of information, but also to present them conveniently and effectively to the user. Data visualization, its structure, color scheme, dynamics of presentation - all this forms the overall impression and affects the quality of perception. In this regard, intelligent systems that are able not only to store and process data, but also to adapt their presentation to the user's needs are becoming increasingly important. One of the most promising tools for this is artificial neural networks, which model the work of the human brain and are capable of learning based on accumulated data. The use of neural networks allows you to analyze large amounts of information, find patterns and automatically make decisions. Thanks to machine learning technologies, such systems can be used in various fields - from marketing to medicine, from banking to scientific research. At the same time, the process of training a neural network, adjusting its structure and optimizing the interaction of its components is a complex task that requires the use of a number of methods, in particular analysis and object-oriented design. In the following part, we will consider how, based on these methods, an information system was developed based on an artificial neural network that solves a specific problem and uses a genetic algorithm for self-learning and improving its performance [6].

During the study of the subject area, a number of scientific methods were used, in particular analysis. The analysis method allowed us to consider the structure of an artificial neural network, its constituent elements and the features of their interaction. Thanks to this method, some areas of use of neural networks, in particular machine learning and some methods of training such networks, were also considered.

Based on the results obtained by the analysis method, an information system will be developed using the object-oriented design method. The following concept of an information system was chosen, that is, the goal and means by which the system can operate to achieve this goal and what exactly these means require in order for them to be used.

The concept of the product information system is to display the result of the neural network to solve a certain problem. Network training, that is, bot training, will occur using a genetic algorithm, which assumes the presence of generations. The presence of generations assumes the connection of settings (weights of network neuron inputs) between each batch of bots, which can be called the genotype of individuals [8].

Using object-oriented design, logical objects were defined into which the structure of the neural network can be divided for its further comfortable software implementation, which combines not only the efficiency of the network, but also preserves its readability for maintaining and studying its work by other developers. The found objects contain attributes and methods that are used to implement the behavior and operation of a real-world object from which it was taken as a prototype for solving the task. This is necessary for the possibility of using object-oriented programming when creating a product.

The artificial neural network used must meet certain requirements that arise from the purpose of the project and the specifics of its implementation.

The network diagram is shown in Figure 2.

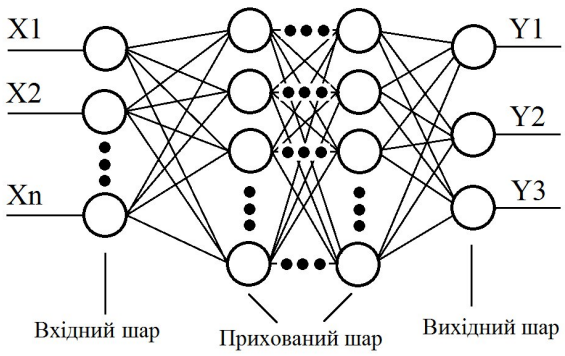

Figure 2 – Scheme of the project's artificial neural network

Since the peculiarity of the solution to the project problem provides for the possibility of configuring the neural network used, the diagram clearly shows that the number of input neurons can change as well and the hidden layer of the network can have a different number of layers and neurons in these layers [4].

Network training is implemented using a genetic simplified algorithm. At the end of each generation, the best bot is selected and its genome is used to create new generations as follows: half of the new population receives the winner's genotype with a 10% chance of mutation, the other half of the second one receives the genotype with a 50% chance of mutation, one individual receives a new genotype, as here the mutation chance is 100% and the last individual receives the genotype without changes. Since the genetic algorithm operates by chance, this means that the mutation can have both a positive and a negative effect.

Conclusions

In the modern information space, where terabytes of data are generated daily, the issue of their effective processing, analysis and presentation is becoming extremely relevant. Traditional algorithmic approaches are not flexible enough and resource-intensive to solve problems related to pattern recognition, forecasting or data classification. In this context, artificial neural networks (ANNs) appear as a universal tool capable of imitating the cognitive processes of the human brain, learning based on statistical data and independently adapting their behavior to achieve set goals. The use of object-oriented design methods allows you to create an effective and scalable information system based on ANNs, which solves a specific problem with the possibility of automatic learning using a genetic algorithm. Such a system provides flexible configuration of the network structure, optimization of its parameters and increasing the accuracy of solving the problem with each new iteration.

The synergy of big data, visualization technologies, and intelligent systems opens up broad prospects for scientific institutions that can use these tools both for the analysis of open scientific data and for the popularization of knowledge. The combination of artificial intelligence and open science is becoming a powerful factor in transforming approaches to the preservation, processing, and dissemination of knowledge in the digital age, contributing to sustainable development, innovation, and increased efficiency in various fields of activity.

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