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Possible Areas of Application of Artificial Intelligence in Libraries and Information Centers

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Abstract—The concept of artificial intelligence arose in the middle of the 20th century, but the rapid development of one specific area for the implementation of artificial intelligence, namely, neural networks, has only occurred over the past 10 years. Neural networks have come to process huge amounts of information, extract its essence, compose a coherent text on their basis that cannot be distinguished from a human one, and conduct a conversation, taking context into account. These capabilities of neural networks can find everyday use in library activities for automatic annotation of documents, cataloging images, searching for similar documents, analyzing bibliographic references in scientific articles, and so on. Then, the information stored in libraries can be used to train neural networks.

Keywords: library, artificial intelligence, neural network, neural network training, annotation, search, generative transformers

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INTRODUCTION

By the middle of the 20th century, the capabilities of electronic computers had reached a level such that the speed of operations performed on them surpasses human capabilities. After the leadership in performing routine computing operations finally passed to computers, the question of the implementation of their creative activities remained open. If until this moment only philosophers wondered whether machines could think like humans, then in the middle of the last century, mathematicians, programmers, and engineers were actively joining in the discussion of this issue. The concept of artificial intelligence emerged, which has many interpretations, but in the context of this article, it is appropriate to use the following: artificial intelligence is the property of artificial systems to perform creative functions that are traditionally considered to be the prerogative of humans [1].

In 1950, Alan Turing proposed a test to determine whether a machine is as intelligent than a human [2]. The essence of the test is as follows: a person interacts with one person and one computer. No participant can see another—the tester asks questions and receives answers from a person and from a computer. From this conversation, a person must determine who is the person and who is the computer program. The computer's job is to mislead the person into making the wrong choice. This Turing test represents a significant reduction in necessity for creativity in computing systems, so tools quickly emerged to help computers pass it. In particular, as the test is based on a series of questions and answers, the advent of LISP (LISt Processing language), which is based on convenient work with lists, including strings, combined with the use of simple techniques for constructing a conversation, allowed the computer program to formally pass the Turing test, but obviously, this has nothing to do with the creative component of the thought process.

Another classic milestone in the development of artificial intelligence was chess game that took place in May 1997 between Garry Kasparov and the IBM computer Deep Blue. In that match, the computer defeated a human, but, as in the case of successfully passing the Turing test, it is not entirely appropriate to talk about artificial intelligence here. Instead, IBM created a very good algorithm for solving one specific problem, and this algorithm was based on searching and comparing possible positions during the game with the subsequent cutting off the directions of game development that would lead to a deterioration in the computer's position [3]. Then, additional optimizations were built into the program to use scenarios from other games, which were used at the beginning and end of the game. All of this allowed the computer to prevail over a person, but ultimately, the algorithm was based on a banal search of combinations, which indicates the amazing speed of the computer but nothing about any creative component of its programming.

NEURAL NETWORKS

Some time after the term "artificial intelligence" appeared, various approaches were developed to create software and hardware systems that would allow computers to reach certain levels of success in creative activities. One such approach was machine learning technology using neural networks, which has received significant development in the last few years.

A neural network is an attempt to model processes occurring in the human brain. It consists of many simple processors, each of which can receive a signal, influence it, and send this signal further. All processors are combined into a complex structure, to the input of which data can be submitted: these data, having passed through a network of processors, are converted and output as a result [4].

Working with a neural network has two stages: training and use. During the learning process, specially selected data is fed to the input of the neural network, and the resulting result is evaluated based on how near it is to the desired output. Depending on this assessment, the neural network changes the impact coefficients of individual processors in its network to select them in such a way that the result is as close as possible to the desired one. From a mathematical point of view, learning is a multiparameter nonlinear optimization problem.

During operation, a correctly trained neural network, when receiving similar, but not equivalent, input data, can produce a result close to the one it was trained on. Neural networks are successfully used in tasks such as pattern recognition. For example, a neural network trained to find a cat in a picture will, with a high degree of probability, be able to find a cat if it is given an image as input that was not involved in training the network.

This may be one of the areas of application of neural networks in libraries, such as automatic tagging depending on what is depicted in the illustrations of works stored in a digital library to facilitate subsequent search through images.

The most difficult thing about neural networks is training them. Many problems can arise during this process. Some of them are related to settings and training parameters. For example, the network may not have been trained optimally. This means that the solution to a nonlinear optimization problem is a certain local extremum, not a global one. However, in the training of a neural network, most of the problems are related to the data on which it is trained.

One problem is the lack of data to train a network. In this case, the network actually "remembers" the correct answers, rather than learning to look for some kind of relationship in the input data. Another problem is the poor quality of the data on which training takes place. This problem is known as garbage in, garbage out. The fact is that a neural network trained on low-quality data is not capable of producing anything worthwhile when it receives high-quality data as input, as it has never encountered it and is not trained on how to respond to it correctly.

Thus, to properly train a neural network, a large amount of high-quality data is required. This plays exactly to libraries' strength: they store a huge amount of information that has undergone editing, and scientific publications are also peer-reviewed. Therefore, another possible intersection between the activities of libraries and the development of neural networks is the provision of a large amount of high-quality information stored in libraries for training networks [5].

Development of Neural Networks

Ideas about the structure and functioning of neural networks arose in the middle of the 20th century, but they became widespread at the beginning of the 21st century. This is most likely due to the development of the production of element base for microchips. Technology has reached such a level that almost every modern phone has a built-in neural processor containing billions of nodes in its neural network. The development of neural networks is strongly influenced by the emergence of programming languages aimed at optimizing human efforts in their training.

Both of these factors have led to the fact that even engineers and programmers who create neural networks, select data for training, write algorithms for, conduct training for, and test them, cannot predict what the network will produce if it is given certain data as input. The fact is that in neural networks, between the process of creation and the process of use, a learning process appears, the result of which is impossible for a person to calculate, as it is physically impossible for a human to analyze the work of billions of neurons.

Perhaps because of the unpredictability of the final result, as well as because of the accessibility and ease of use, neural networks have become so widespread. Even out of curiosity, a person may be interested in entering some kind of request on his phone or in a special program on his computer and get a result that he could not predict, but which, at a minimum, does not contradict his request. This "wow" effect fuels public interest in introducing neural network technology into various aspects of life.

In 2017, an experiment was conducted at the Russian National Library (RNB) using the neural network Watson, developed by IBM. At that time, the idea arose at the Russian National Library that the search for scientific publications should be different from the search for works of art. Often the search is carried out using keywords that the user enters as a search query. Additionally, the searcher can introduce restrictions on a number of parameters: year of publication, publisher, title of works, author's surname, etc. In any case, the search is carried out using keywords. We assume that a researcher, an expert in a particular field

and having publications on this topic, is interested in searching for publications that somehow intersect with his field of interest. In this case, instead of isolating keywords from his publication, entering them as a search query, and then trying to rank the search results, this employee can submit some of his articles as search data, and the neural network will analyze it and select those publications that are similar to the original one.

In 2017, the neural network Watson analyzed all abstracts on history that were stored in the electronic library of the National Library of Russia. For a search query, Watson was offered randomly selected history abstracts from the same set. Obviously, the same abstract that was submitted as a request appeared in the first place in the list of results. In the overwhelming majority of cases, what followed was a list that, according to experts, was not relevant to the original abstract, although quite rarely the neural network produced a result that was not expected by the experimenters.

In particular, we provide the example of an abstract on the economy of the Trans-Baikal region in 1921–1924 that was submitted for entry. It is expected that this abstract itself would be in first place and that in the following places would be abstracts devoted to the economy of the Trans-Baikal region, but in other years, for example, 1918–1921 or 1924–1927. However the experimenters were amazed that in the following positions of the search result, Watson produced abstracts devoted to the economy of neighboring regions of the same or adjacent periods: for example, the economy of the Baikal region in 1921–1924.

Unfortunately, these amazing and unexpected results were produced by Watson only in less than 10% of cases, which was catastrophically insufficient for introducing this search technology into commercial use. After that time, the number of nodes used in neural networks grew significantly, and the technologies for training, testing, and filtering obviously inappropriate results reached a qualitatively new level, which makes it possible to return to experiments in searching for literature in libraries not only using keywords but also searching for similar texts.

Generative Transformers

During the middle of the second decade of the 21st century, researchers began to focus their efforts on creating generative pretrained transformers (GPT). GPTs are a type of large language model trained on large sets of text data and are capable of generating human-like text. The pioneer in this direction was OpenAI, founded in 2015 by Elon Musk and Samuel Altman [6]. At the end of 2022, this company launched a chatbot featuring artificial intelligence, ChatGPT, which caused a surge of interest due to its great capability for conducting a dialogue with the user, taking context into account and generating texts that are almost impossible to distinguish from human speech.

ChatGPT is based on the GPT-3.5 language model, an improved version of the GPT-3 model. In turn, the GPT-3 model used data sets in various languages with a total volume of 570 GB of texts for training. The developers of GPT-3 trained eight different models whose architectures were similar to each other but differed in the number of machine learning parameters. The maximum model has 175 billion machine learning parameters [7]. This has allows for GPT-3 to be able to answer questions about a text read, compose poems in a given style, solve mathematical examples, and generate texts on a given topic.

In 2015–2016 The Russian National Library conducted a large-scale study of how users read books posted in the Russian National Library's electronic library. The study was conducted from March 10, 2015 to August 31, 2016. During this period, 1 932 603 books were opened in the NLR electronic library, and 20 376 397 pages were viewed. Thus, on average, users view 10.54 pages per book. We can conclude that the main user scenario is as follows: searching for books in an electronic catalog using a search query, selecting several books in the search results, opening selected books, becoming familiar with the first few pages on which the abstract and table of contents are located, and closing the book. This user behavior signals that the information presented in the search results is not enough to decide whether to read the book: the person needs to open it and read the first few pages. Then the idea arose that placing a small summary on the search results page could help the user make a more informed decision about whether to read the book.

In 2016, the Russian National Library conducted an experiment using the Watson neural network to automatically generate annotations based on the text of a book. This experiment was considered a failure because the generated texts were incoherent, contained a large number of errors, and irritated readers.

Recent studies show that ChatGPT outperforms humans in the text annotation task. For example, in an experiment conducted from March to May 2023 on 6183 tweets and newspaper articles, ChatGPT outperformed hired employees in the tasks of determining the significance of the text, the political position taken, the subject of discussion, and identifying the structure of the message [8]. It is quite possible that it makes sense to return to the experiment on automatic text annotation conducted at the Russian National Library in 2016, using modern neural network models.

Thus, another possible area for using artificial intelligence in libraries is the automatic creation of annotations for e-books using generative pretrained transformers.

Creation of Scientific Articles

Modern image editors often have a built-in option that allows them to "improve" a particular photo using artificial intelligence. Moreover, in the latest generations of Apple iPhone smartphones, a similar functionality is built into the standard Camera application and cannot be disabled. From this, the question arises: how does the software understand what constitutes an improvement and what does not? After all, all people are different, and what is an improvement for one user, for example, reducing the nose and enlarging the lips, is absolutely unacceptable for another.

Most likely, the "enhancement" function is configured individually, depending on the user's history of editing their own photos. If a someone changes the same part in all original photographs, then we can conclude that it is this transformation that is considered an "improvement" in this user's understanding. The software can save the original version of the image and the version created by the user, and, by comparing these versions, identify a pattern of changes that the person uses over and over again. Perhaps applying this template to a photo as the user takes it will produce an image that the phone owner is more likely to like.

Just as a phone user edits photographs over and over again, bringing them to perfection, in the same way a researcher works on publications, changing the structure, the location of blocks of text, supplementing the article with facts, and paraphrasing using various stylistic turns. Theoretically, it would be possible to create a neural network and train it on an array of intermediate versions of the author's publications so that the network can identify characteristic patterns of changes that are inherent in this particular author, and in the future, it could be able to use these patterns to "improve" the researcher's articles at the editing stage.

Another routine part of the creation of a scientific article is working with lists of bibliographic references. Neural networks are quite capable of understanding at what point in a scientific article the author refers to data from another article, correctly formatting a quotation or link to a source, and adding a reference to the original article to the bibliography in the standard accepted by the rules of the journal or institution in which the author works. Neural networks can automatically check all bibliographic references found in an article for accuracy, correctness, and compliance with sources, as well as the consistency of the information provided with the data from the article to which the link is given.

CONCLUSIONS

Over the past 10 years, significant progress has been made in the development of neural networks. What they produce in response to user requests is amazing and, at the same time, discouraging. Broadly, texts generated by neural networks cannot be distinguished from those written by humans. The coherence of the text, the logic of the narrative, and the observance of cause-and-effect relationships in these texts allow them to qualify for the title of a scientific article.

Unfortunately, it is impossible to say that artificial intelligence can perform creative functions. In fact, it has only learned how to work with huge amounts of information, isolate some data from them, put them together and present them to a person in the form that is familiar and convenient.

Using the principle of self-applicability, it has become fashionable among researchers to ask, for example, ChatGPT what it thinks about a particular problem related to artificial intelligence. In particular, when asked whether artificial intelligence is capable of writing a scientific article, ChatGPT honestly answers that it is only capable of generating a large amount of text on a given topic, but this will in no way be original research, as this text will be based on existing developments, i.e., this generated text will not contain any new ideas, approaches, or conclusions [9]. Thus, it is too early to say whether artificial intelligence and neural networks, as types of implementation of artificial intelligence, are capable of truly creative activity in the broadest sense of this concept.

However, at the current stage of development of neural networks, we can conclude that they can make it easier for librarians to perform operations that are not directly related to the creative component, namely:

- automatic tagging depending on what is depicted in the illustrations stored in the electronic library of works to facilitate subsequent search through images;
- search the electronic catalog, not only using keywords but also searching for similar documents based on a full text;
- automatic annotation of scientific articles and books stored in an electronic library;
- use of article editing templates specific to a particular researcher;
- analysis of bibliographic references for accuracy, correctness, compliance with sources, and consistency.

In turn, libraries can act as suppliers of the large amounts of verified data that neural networks need for training.

Thus, we can assume that over the coming years we will witness mutually beneficial cooperation between the library community and hardware and software systems based on the use of artificial intelligence systems.

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CONFLICT OF INTEREST

The author of this work declares that he has no conflicts of interest.

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