Some Aspects and Prospects of Artificial Intelligence Application in Educational Processes of the Agricultural Sector of the Economy

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Abstract

This article is devoted to the study of some aspects of the application of artificial intelligence in the educational processes of the agricultural sector. Challenges that remain in agricultural education today are considered. The main areas of possible application of modern results obtained in the field of artificial intelligence for the improvement of educational processes in agriculture have been studied. A new look at the current state of information protection of intelligent systems for increasing the yield of agricultural crops is offered. In addition, the prospects for the application of research results in the field of generative artificial intelligence and the main directions of virtual reality in the field of agricultural education are considered.

Keywords

artificial intelligence, educational space, agricultural sector, scientific research

1. Introduction

Digital transformation is changing the way most organizations operate and deliver services. The use of various technologies, such as artificial intelligence, machine learning, big data, the Internet of Things, cloud computing, etc., will improve the state and quality of organizations. To a large extent, this also applies to agricultural companies. Using these technologies, the company can better describe situations, be more flexible in the face of turbulence, as it can better predict and apply the recommended strategies for the organization. Innovations in business processes, driven by the reengineering of business processes based on digital technologies, are a key factor in digital transformation [1]. In addition, it can be considered that artificial intelligence is one of the main modern tools for innovation [2].

When implementing most new technologies in the agricultural education sector, one should remember the importance of the triad L-P-T (People – Process – Technology). In some cases, the human factor of this triad is ignored because most organizations focus only on the technological aspects of this triad. This is due to the obvious reality that employees need more time for training, development and more financial support. At the same time, it is obvious that employees of any sphere of human activity are of decisive importance and often they are the ones who determine the success of the introduction and adaptation of new technologies. It is certainly true that strategic workforce

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planning in determining the direction of development of the agricultural sector should include the development of technologies, and in particular, the introduction of artificial intelligence. It should also be noted that the introduction of new education technologies and the latest technologies in education is a key factor in training employees of agricultural enterprises and organizations.

Today, the automation of training processes in organizations mainly consists of data input, automatic processing, storage, and output. Artificial intelligence can help to make the process of automating learning processes and procedures in agricultural enterprises and organizations smarter, more efficient, and more accurate.

An illustration of the application of artificial intelligence and the use of modern artificial intelligence technologies is presented in Figure 1. It should be noted that Figure 1 is not an illustration of the sequence of AI implementation or the priority of application of the components of this process.

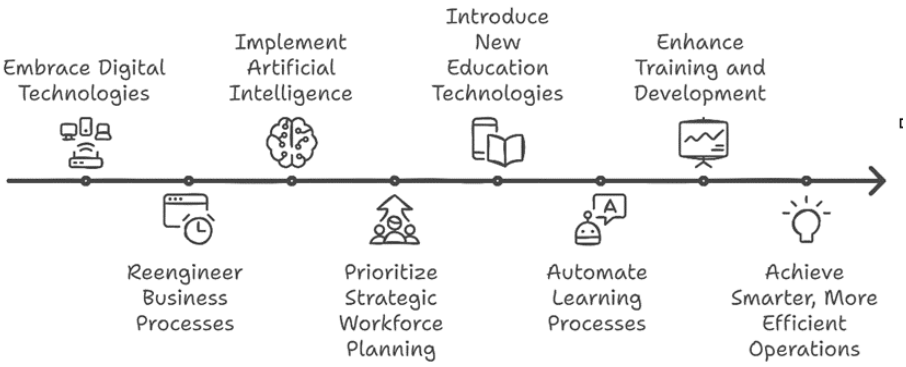

Figure 1: Leveraging artificial intelligence for digital transformation in agriculture.

2. Aspects of artificial intelligence application in educational processes

2.1. Types of cooperation at the current level of artificial intelligence development

The main types of cooperation that can be used in the classrooms of modern agricultural enterprises and organizations are as follows:

- parallel arrangement, where students receive the same instruction, looks like a traditional classroom model;
- clear order: in this model, each group works on a separate task: the desktop is a semi-private workspace for everyone involved in the learning process;
- general organization of the educational process, when cooperation between groups is possible and collective discussion of emerging problems takes place in a large class.

Artificial intelligence can help automate key activities in education and learning processes in the agricultural sector, such as assessment. In particular, educational programs can be adapted to the needs of students. Artificial intelligence can point out areas where courses and individual disciplines need to be improved. Students can get additional help from automated AI tutors. AI-based software can provide useful feedback to students and teachers [3, 4]. Artificial intelligence is also changing the way we find and interact with information.

2.2. Directions of using artificial intelligence in the agricultural education system

The main areas of application of artificial intelligence in the education system in the agrarian direction today are:

- helps employees of agricultural enterprises and organizations learn at their own pace;
- helps to identify human needs more accurately;

- helps to eliminate bureaucracy in the educational units of the agricultural sector of the economy;
- provides control over the rationality of time spent on training;
- directly and indirectly increases the quality of the agrarian direction of education;
- ensures ergodicity in the educational process for teachers and students;
- is used to support decision-making through rapid data analysis;
- ensures planning of training in accordance with the abilities and pace of mastering academic disciplines by students;
- uses the latest approaches and a well-grounded choice of effective teaching methods by analyzing the dynamics of the educational process;
- creates an opportunity to practice small group learning with effective planning of training procedures;
- Ensures the effectiveness of the individual learning process in agricultural organizations and enterprises.

The areas of application of AI in agricultural education are presented in Figure 2. It is clear that the presented list of areas is not complete. It is obvious that it cannot be complete and final, since this industry is currently developing rapidly and successfully.

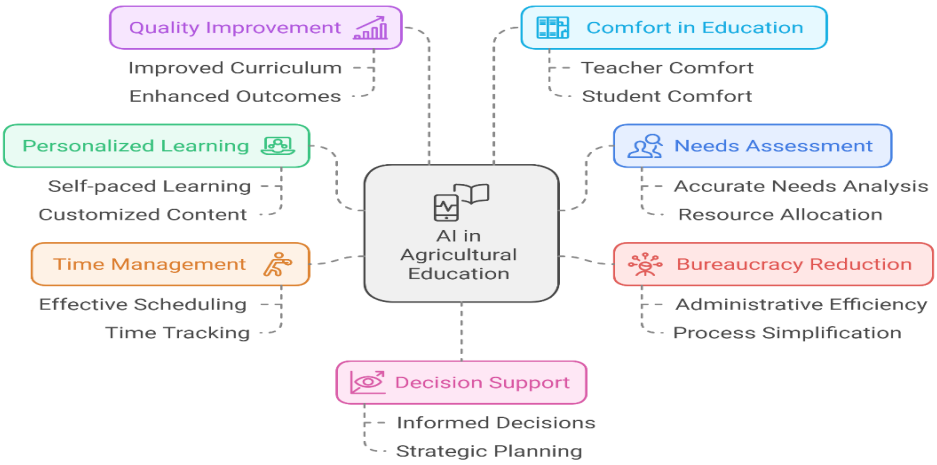

Figure 2: Areas of AI application in the training system in agricultural organizations.

Artificial intelligence also provides an opportunity to train agricultural managers to make decisions based on actual tasks in production conditions using virtual reality [5].

2.3. Problems of using artificial intelligence in agricultural education and approaches to their solution

The main existing problems in agricultural education and some approaches to their solution with the help of artificial intelligence are listed in Table 1.

The ability to identify students' individual skills and develop them in the specific specializations for which they have the greatest aptitude. As a rule, students cannot have fully practical skills and are not ready to work in real conditions [6]. Therefore, the best solution in such situations is to train using virtual reality technology.

In addition, artificial intelligence can be used in agricultural training systems in such cases [7, 8]:

- academic analytical assessment of students using an adaptive teaching method and a personalized approach to learning;
- Assessment of module tests, quizzes, and exams using image recognition, computer vision, and prediction methods, as well as learning analytics using data sets;
- a virtual personal assistant for real-time analytical learning;

- intelligent automation of educational materials and processes;
- creation of automatic training programs using augmented intelligence, focused on the specific needs of students;
- interaction with students and teachers based on the latest achievements of artificial intelligence in the field of communications [9, 10];
- support for students with disabilities and health problems using robotics and virtual reality;
- Preventive identification of students at risk of dropping out, helping them to reduce dropout and expulsion rates;
- learning a foreign language by recognizing and analyzing speech, correcting pronunciation and correcting errors, reducing the percentage of errors at the current level of development by an average of 83%;
- Ensuring the improvement of the quality of decision-making in educational organizations of the agrarian sector with the help of artificial intelligence;
- adaptation and personalization of training programs based on users' knowledge, interests, and strengths;
- creation of individual textbooks for a specific organization, a division of an organization, or even a separate group of students at an agricultural enterprise.

Table 1
Problems in education and their solutions with the help of artificial intelligence

Number	Formulation of the problem	Solutions for artificial intelligence
1	Standardized curriculum does not meet individual needs	Personalized education
2	Limited tutor working hours	Personalized virtual teachers
3	Large number of students in the classroom, many questions that cannot be answered	Virtual classroom assistants
4	Personalized communication is very difficult for a large number of students	Chatbot quickly answers administrative questions
5	Justified selection of the best students from the applications	AI can make criteria-based choices using the entire set of provided vessel data
6	Increased dropout rate of students who failed to learn the material	Sentiment analysis using artificial intelligence
7	The complexity of analyzing the success of the learning experience	Complements existing learning analytics by providing timely information about students' successes, problems and needs, which can be used to shape the learning process
8	Difficulty in tracking other skills	AI develops reliable and accurate metrics to track student progress, including hard-to-measure traits such as creativity and curiosity
9	The need for teachers to provide a significant amount of clerical administrative work	AI acts as an intelligent server to perform clerical tasks. However, the final decision still rests with the teacher, as human intelligence remains in demand
10	A "stop and check" approach to evaluation	AI can perform qualitative analysis, sentiment analysis, and provide personalized and individualized assessment, as well as provide role-playing and collaborative projects as part of the assessment method

11	Provide new knowledge that is difficult or impossible to obtain through traditional assessments	AI can analyze various data sources, correlate and visualize them so that teachers can better understand students

2.4. Main areas of artificial intelligence application

Here are the main areas of artificial intelligence application:

d_1 – Control of the educational process;

d_2 – Management of the educational process in the departments of agricultural enterprises and organizations;

d_3 – Effective cooperation in the learning process.

Each of the above areas is characterized by several basic functions and can be formally represented as a certain functionality:

$$d_1 = d_1(\varphi_{11}, \varphi_{12}, \varphi_{13}), \tag{1}$$

where φ_{11} – facilitates the faster completion of administrative tasks that require significant time, such as surveys, grading of module tests, quizzes, exams, etc. and providing feedback;

φ_{12} – Assisting teachers in decision support and data-driven processes;

φ_{13} – timely and direct work with each student to receive feedback and generate managerial influence;

An example of equation

$$d_2 = d_2(\varphi_{21}, \varphi_{22}, \varphi_{23}, \varphi_{24}, \varphi_{25}), \tag{2}$$

where φ_{21} – predicting how well a student will exceed expectations in projects and exercises, as well as extrapolating the dropout rate depending on the current state of learning and analyzing the dynamics of the learning process;

φ_{22} – helping teachers create individualized curricula for each student;

φ_{23} – helping students learn outside of the classroom and supporting potential effective collaboration;

φ_{24} – customizing the learning style for each student based on their personal information;

φ_{25} – analysis of the proposed curriculum, academic disciplines and course materials;

$$d_3 = d_3(\varphi_{31}, \varphi_{32}, \varphi_{33}), \tag{3}$$

where φ_{31} – identifying deficiencies in student learning and eliminating them at the initial stages of learning;

φ_{32} – customizing the learning path for each student based on the collection of learning data;

φ_{33} – Identification of learning situations, application of intelligent data processing about the characteristics of learning situations, and timely adaptive intervention in the student learning process.

To visualize the interaction of the functionalities of the form (1)-(3), let us summarize in Table 2 the main functions of artificial intelligence that can be used in the training processes of agricultural enterprises and organizations.

A positive feature of the proposed approaches to the organization of learning processes in agricultural organizations and knowledge testing is the transparency of the rules set a priori by the test organizers, the absence of situations of uncertainty during the assessment procedure, and the monotonic behavior of the function that reflects the integral assessment of answers. In accordance with the proposed technology, determining the resulting assessment of students of agricultural organizations and enterprises is a reasonable and formalized procedure. It is obvious that the technologies of agricultural education, based on the use of artificial intelligence, allow us to further improve the approaches and directions described above [11].

3. Challenges of the current stage of artificial intelligence development in the field of agricultural education

Today, Western experts claim, or simply report, or perhaps only suspect, that artificial intelligence could deprive 40% of the world's population of their jobs within two years. And in developed economies, it will be 60% of jobs. And in simpler, non-technological civilizations, artificial intelligence will soon affect about 40% of the working population. Such forecasts certainly apply to the educational infrastructure of the agricultural sector. Therefore, this area should be constantly in the focus of attention of scientists and requires a prompt response to modern challenges [12].

Table 2
The main directions of using artificial intelligence

Number	Formulation of the problem	Solutions for artificial intelligence
1		φ_{11}
2	$d_1 = d_1(\varphi_{11}, \varphi_{12}, \varphi_{13})$	φ_{12}
3		φ_{13}
4		φ_{21}
5		φ_{22}
6	$d_2 = d_2(\varphi_{21}, \varphi_{22}, \varphi_{23}, \varphi_{24}, \varphi_{25})$	φ_{23}
7		φ_{24}
8		φ_{25}
9		φ_{31}
10	$d_3 = d_3(\varphi_{31}, \varphi_{32}, \varphi_{33})$	φ_{32}
11		φ_{33}

It can be confidently generalized that the cause of most wrong decisions and severe consequences of such decisions is primarily misplaced priorities. The problems of human civilization have their origins in misplaced priorities, which is reflected at the household level, in the field of state building, in the field of international relations, and even at the global level. The agrarian sector should also take care of modernizing production, the educational component, and setting the right priorities to adequately respond to the existing challenges [13].

You should pay attention to the peculiarities of setting up the modern version of generative artificial intelligence. The paradigm of its use is to provide answers to any questions without fail. These answers must be formatted correctly, and artificial intelligence does not apply any analysis to determine their correctness. For example, when studying preferential voting, the authors decided to partially use ChatGPT services. This approach is known to be used in many countries. Its essence lies in the fact that in a situation

of choice, we do not say that we want to vote for any one candidate, whether for president, deputy, or any elected body, but rather rank these candidates – several at once: three, five, that is, we establish a multiple comparison of alternatives. When preparing the next study, the authors asked artificial intelligence: which countries use preferential voting? It was known in advance that these were Hungary, the United States, and the United Kingdom. The first answer was, of course, correct. But what other countries? And so, the authors asked additional questions: "What other countries, what other countries?", the artificial intelligence named another hundred countries. Although this is not the case in real life. That is, it was demonstrating the author's knowledge of geography and trying to answer something offhandedly, just to avoid leaving any more questions unanswered.

That is, in future versions of artificial intelligence, it would be advisable to provide one of the main options for an expert: the ability to recognize the limits of their competence. If the questions go beyond the limits of competence, the interviewer should definitely be reminded of this. This factor is especially important for agricultural educational programs.

In many practical situations, it may seem that the most valuable thing is being taken away from us – the joy of creativity. We all feel this joy when we create something new, create new algorithms, models, some new knowledge, create new knowledge by our own efforts. And today, it sometimes seems that you can turn to artificial intelligence and it will quickly generate new ideas, solve all current problems, and respond quickly and effectively to new challenges. This is exactly what the authors of this article see as a danger, in particular for activities in the agricultural education sector.

In 1961, the German writer Herbert Werner Franke, perhaps you've read it, wrote a fantastic novel called The Archdevil's Cage, which became a bestseller. It was a science fiction novel in which people landed on a planet and saw what the humanity there had brought itself to in the pursuit of pleasure and the desire to transfer all efforts to external mechanisms. In the process of their artificially created millions of years of evolution, these representatives of an intelligent civilization turned into creatures that are not suitable for active life. They had only the rudiments of a heart, brain, lungs, and other organs. Outwardly, they became very similar to archaea, hence the title of the work. So, if we were to follow a similar path that artificial intelligence offers us today, something could happen to humanity in millions of years. This is what Herbert Franke believed. But, on the other hand, we know this, and at the previous stages of artificial intelligence development, we saw all sorts of potential ethical problems. Over time, it turned out that not everything is so scary, not everything is so complicated, and that this area will develop in the future, and in ways that we are not even aware of now. We all know that there is such a thing as the logic of a business.

Ground robots and flying drones are now widely used in the agricultural sector, digital agronomy is intensively developing, and agricultural education is improving. The areas of application of new technologies and their equipping with artificial intelligence are intensively multiplying. In this regard, it is high time to discuss ethical issues around this phenomenon [14, 15]. But today, when we hear daily air raids, learn about the arrival of missiles and guided bombs in different cities and villages of Ukraine, and learn about the victims of terrorist attacks, it becomes obvious that we should be afraid of natural, human intelligence. It is he who creates such dangerous situations for us that we are now facing every day. And we will cope with the challenges and potential dangers posed by artificial intelligence by working together.

Today, it is obvious to everyone that humanity is at a bifurcation point, and predicting anything at such unstable points is a thankless task. Once upon a time, one of my colleagues, a successful development manager, claimed that he could easily multiply three-digit numbers, but there was a high probability of error. So, when we are going through a period of development that corresponds to a bifurcation point, when predicting something, you can find yourself in the position of such a manager.

Threats and challenges of artificial intelligence also pose a direct and immediate threat to higher education and education in general, and in the agricultural sector in particular. Nowadays, students

are much more likely to use GPT chat and similar generative models for learning. I am very worried because many students, unfortunately, not all of them, certainly use GPT chat for not very ethical purposes, so to speak. Remember, there were threats, as soon as computer viruses appeared a few decades ago, antivirus programs and entire corporations that specialized in this protection against viruses appeared accordingly. I have this dream: to constantly create and improve software that will allow us to distinguish with a high probability that this is not a human product, but an artificial intelligence product. That is, software detectors to identify artificially created works, or with significant involvement of unnatural intelligence. Such works should have a note on them: "not created by man". Just as marked banknotes are used to fight bribe-takers, so dishonestly created works should be marked accordingly. The draft law on academic integrity provides for liability for writing scientific papers using artificial intelligence and plagiarism in scientific activities.

It is worth noting that artificial intelligence has two components: theoretical and pragmatic. A few decades ago, expert systems began to be created on a massive scale. Some people thought that this was the thing that would save us, that practical artificial intelligence had finally been created. And what did the further development of this practical component lead to?

It seems to me that it is impossible to assign weights here, well, weighting coefficients, these will be some kind of membership functions that need to be built in order to determine these weighting coefficients more adequately. In particular, because of the aforementioned bifurcation point in which we happen to live.

There are two approaches in general and two models of science development: some believe that science develops from practical needs, while others follow a different scheme – science is created to make people's lives easier and to encourage their laziness. People who are too lazy to count from one to one hundred take a formula and create it, just like the young Carl Gauss did in his time.

The ratio between these two areas of artificial intelligence development is roughly the same, whichever one outweighs the more practical or theoretical aspect, and the faster we develop these areas, the better. So far, I see a 50-50 ratio between practical and theoretical artificial intelligence. I think this ratio will be observed in the next few years.

4. Artificial intelligence and digital humanities at the current stage of development of agricultural education

Digital Humanities is one of the levers and, in some areas, even a tool for a successful way out of the current crisis, the point of bifurcation in which humanity finds itself. It is especially important and promising that within the framework of digital humanities, intellectual and technological achievements of information technology are combined with the achievements of the humanities. In many practical cases, this alliance results in a significant and obvious synergistic effect. Many areas of cognitive research today are characterized by the systematic use of information technology in the humanities, and, most importantly, it naturally generates reflection on the quality and prospects of using the latest technologies [16]. Multi-million-dollar grants are used to create a framework of digital competencies for teachers and other citizens, and to formalize elements of education at the sectoral, intersectoral, national, and global levels [17].

It is already clear that, in addition to the positive and significant potential opportunities, artificial intelligence is a source of significant risks and potentially negative impacts on society, its various institutions, and, of course, and to the greatest extent, its individual members, in various manifestations and areas of influence:

- reduction and even leveling of the level of intellectuality, curtailment of creativity and breadth of thinking – human activities that bring pleasure, are the source of personality universalism and fill our lives;
- a decrease in the level of critical thinking of researchers, which can lead to unpredictable consequences;

- leveling the application and deterrent effect of the critical approach methodology, etc.

With an uncritical approach to interdisciplinary research, there are a significant number of pitfalls that can negatively affect the overall development and improvement of digital humanities:

- professional terms are transferred with unacceptable ease – not only to related fields of study, but also to fields of study that are obviously unrelated;
- The results are naturally distorted due to artificial confusion in the methodology and research methods;
- possible unnatural interpenetration of research tools, viral diffusion between biology, medicine, other fields, and information technology;
- primitive transfer of the meaning of professional terms from the field of information technology to the field of the subject area under study at different levels and scientific fields;
- there are risks of deliberate duplication of professional terms, which leads to a dangerous and unreasonable complication of the research base;
- scientific terms may be used incorrectly due to the substitution of concepts.

Here are just a few examples:

- computer viruses and their behavior are interpreted as natural viruses;
- computer networks are becoming a testing ground for the study of epidemics in human society;
- Some researchers are trying to describe the diversity of wildlife with primitive mathematical models;
- It is assumed that the introduction and use of similar terms from different fields of research automatically creates a dependence on the course of the process, and creates subordination to the laws of nature.

The negative impact of AI is also largely due to its use for generating various kinds of content that will contribute to the spread of violations of the principles of academic integrity. But this threat should not be exaggerated. It will certainly lead to the emergence of new trends in education that will be aimed at minimizing such violations. In addition, in the near future, technologies will appear to determine whether AI has been used to generate content with the corresponding consequences.

Information technology and artificial intelligence are penetrating many aspects of our lives. AI threatens jobs, but it also creates new opportunities. A powerful and extremely important element of modern agricultural education is the focus on various aspects of environmental protection [16]. According to the latest studies of scientists, agroecological education is currently an important area of agricultural education [18, 19].

The analysis of trends in the development of technologies in general, and information technologies in particular, shows that new results periodically emerge that change our understanding of promising and rational directions of development of society and socio-economic systems.

5. Some aspects of information security of intelligent systems for supporting education in agriculture

In the modern world, agronomy is increasingly dependent on digital technologies and data processing. This includes the use of advanced farm management systems, satellite imagery to monitor yields [20], and weather forecasting.

There is a high risk of targeted attacks on information systems, which may include the spread of malware aimed at stealing data or even altering data, which can lead to incorrect decisions based on distorted information in the field of agricultural training.

It should be noted that for the successful implementation of digital transformations in agriculture in general and agricultural education in particular, a group of necessary and sufficient conditions must be met [21, 22]:

- Necessary conditions: a high level of agricultural education in general, education in information technology, financial support, computer literacy of staff, support for digital strategies by the authorities;
- Sufficient conditions: the possibility of using the Internet and mobile communication in the widest possible area of agricultural enterprises, organizations and educational institutions, improving the skills of staff in digital technologies, creating innovation and digital ecosystems in agriculture, which will ensure the introduction of business incubators, accelerated learning programs, hackathons, etc.

Given the growing dependence of the agricultural sector on digital technologies, protection against such cyber threats requires a comprehensive approach, including regular security assessments and the implementation of modern security technologies.

One example of the creation of protection technologies is some options of the intelligent crop yield forecasting system developed by the authors of this paper, which is a key element for ensuring effective agricultural management. The system is based on processing and analyzing a large array of data, which includes:

- satellite images of fields;
- meteorological data;
- information about vegetation;
- agronomic information about the state of the field;
- detailed information on the agrotechnical measures taken;
- personal data of students;
- information on the achievements of applicants and their educational trajectories;
- information about teachers and researchers of agricultural educational institutions and their scientific and methodological developments;
- other important factors that significantly affect crop yields.

Obtaining the above-mentioned reliable information, its safe storage, adequate analysis, and transmission through secure channels require significant financial, material, and labor costs.

Using this data, the system uses machine learning algorithms to determine the potential productivity of different plots, which allows optimizing the planning of agricultural work and the use of resources [23]. The result of the system is a yield estimate that influences the strategic and operational decisions of agricultural firms [24].

However, due to the high importance and sensitivity of the data collected, the forecasting system faces numerous potential cybersecurity threats. Among the most important and dangerous threats are the following:

- risks of unauthorized access;
- manipulating data for mercenary purposes;
- industrial espionage;
- malicious use of data, etc.

All this can lead to incorrect forecasts and significant losses. Therefore, ensuring the information security of such a system is critical.

5.1. Ensuring information security at the level of system architecture

Cloud storage is used to ensure reliable protection and confidentiality of data. The main advantage of this solution is not only convenient data storage, but also a high level of protection against unauthorized access. Cloud services offer built-in tools for effective access control and data encryption, which minimizes the risks associated with cyberattacks and information loss.

In order to further protect information and prevent unauthorized use of data, a special API has been developed to access the database. This API processes forecasting requests without providing

direct access to the data itself. This approach effectively protects information from potential leakage, ensuring that confidential data remains inaccessible to unauthorized persons.

In the near future, the company plans to solve the problem of ensuring access security to the system by implementing modern authentication and authorization mechanisms based on OAuth 2.0 and OpenID Connect standards. This approach will provide a high level of protection against unauthorized access, allowing to accurately identify system users and provide them with access to resources in accordance with their rights and roles.

The use of the role-based access model (RBAC) will allow you to flexibly configure user rights, effectively delimiting access to the system's functionality. In turn, this will ensure the correct distribution of rights: users will have access only to the data, options, and functions that are necessary to perform their tasks, thereby minimizing the risk of misuse of information about the state of crops, prospects for their processing, and yield forecasts in certain areas of these fields.

5.2. Protection against information attacks in digital agronomy

A critical aspect of information security is the strict validation of all input data received from users. The application of thorough checks for compliance with defined formats ensures that only valid data is processed by the system. This eliminates the possibility of using malicious data to carry out attacks or attempts to hack the system.

Protecting against information attacks requires a comprehensive approach to analyzing and validating incoming data. Malicious data can be designed to disrupt the system by exploiting weaknesses in the validation of data formats. For example, a SQL injection vulnerability occurs when the system directly uses input data to generate SQL queries without properly validating and screening them. This can lead to unauthorized access to databases, leakage of confidential information, or even its loss. Another example is a buffer overflow vulnerability, when processing data that exceeds the expected amount can cause malicious code to be executed. To protect against such attacks, initial validation is performed to ensure that the data conforms to certain formats.

However, there is a more subtle threat associated with incorrect input data, which is not always obvious and may not be intentional on the part of the user. The system is used to predict yields based on a variety of data, including satellite images, meteorological data, and field condition information, so it is important to consider the possibility of introducing distorted data. This can be due to incorrect satellite imagery caused by weather conditions or technical failures, errors in meteorological measurements, or incorrect crop data entry. Such errors can lead to a significant decrease in forecasting accuracy.

To prevent incorrect data from affecting the forecast results, a traditional two-stage approach is used. At the first stage, the key parameters for forecast accuracy are identified and their correct ranges are evaluated by experts. If the data is outside these ranges, it is considered incorrect and removed from the training set.

5.3. Mathematical support of an intelligent system

In order to mathematically describe the process of filtering input vectors by the specified ranges, you can use the following formula. Consider the input vector

$$x = (x_1, \ldots, x_n). \tag{4}$$

Suppose that for each parameter x_i, the range $[a_i, b_i]$ is defined, where a_i and b_i are, respectively, the minimum and maximum valid values for the parameter x_i.

Then the formula (4) for determining whether the vector x is considered correct can be expressed as follows:

$$V(\mathbf{x}) = \left(\bigwedge_{i=1}^{n} (a_i \leq x_i \leq b_i) \right) \tag{5}$$

where V is the validity of the vector x, which indicates whether all components of the vector are within their respective valid ranges.

Expression (5) means that the input vector x is considered valid if each of its components x_i belongs to the corresponding range $[a_i, b_i]$. If at least one component does not correspond to its range, the vector is considered invalid and should be removed from the training set.

The second stage uses clustering to identify anomalies. This is based on the assumption that areas of the field with similar conditions have similar performance indicators. This approach allows us to identify and eliminate incorrect data before using it in the training set, thereby ensuring higher prediction reliability. Clustering is performed by the k-means method using Euclidean distance.

New data is checked for relevance and correctness by analyzing its relationship to existing clusters formed on the basis of historical yield data. Each cluster is a group of data that has similar yield characteristics and reflects typical conditions for certain areas of the field. During verification, new data is compared to the centroids of these clusters.

1. Determining cluster membership or identifying an outlier:

1.1. Let $d(\mathbf{x}, C_k)$ define the distance from the vector x to the nearest cluster C_k, and let ε be a given distance threshold.

1.2. Define the function $I,$, which determines the cluster membership:

$$I(\mathbf{x}) = \begin{cases} 1, & \text{if } d(\mathbf{x}, C_k) \leq \varepsilon, \\ 0, & \text{if } d(\mathbf{x}, C_k) > \varepsilon. \end{cases} \tag{6}$$

where I(x) = 1 indicates that x belongs to the existing cluster C_k, and I(x) = 0 indicates that x is an outlier or a representative of a new group.

2. Checking the compliance of yield values:

2.1. Let y_{new} be the yield value corresponding to the vector x, and μ_k be the average yield value of the cluster C_k to which x belongs (by condition for functions of the form (6), I(x) = 1) δ is the threshold of the permissible deviation.

2.2 Define the function V that evaluates the correspondence of the yield value:

$$V(\mathbf{x}) = \begin{cases} 1, & \text{if } |y_{new} - \mu_k| \leq \delta, \\ 0, & \text{if } |y_{new} - \mu_k| > \delta. \end{cases} \tag{7}$$

where V(x)=1 indicates that the new value has been checked and the vector is stored in the database; when the value of functions of the form (7) is V(x)=0, it means that the data needs to be checked by experts.

If the new data corresponds to one of the clusters, but the yield values deviate significantly from the average values of this cluster, such data is suspected of being incorrect. They are singled out for detailed review by experts who can assess whether there was an error during data collection or whether these deviations reflect real but unusual conditions. In cases where there is no corresponding cluster for the uploaded data, the data is also considered anomalous. This may indicate new, previously unknown conditions that require the creation of a new cluster or the correction of existing models.

This process not only helps to identify and remove erroneous data before it is used in forecasting models, but also ensures that the system can adapt to new conditions, increasing its flexibility and accuracy. In addition, the involvement of experts to analyze non-standard cases ensures that any decision made on the basis of the data is balanced and well-founded.

5.4. Prospects for Researching the Possibilities of Information Protection of Intellectual Systems

In order to detect and respond to potential security threats in a timely manner, the system will include advanced monitoring and logging tools. This will allow not only to track access to data and system resources, but also to quickly identify suspicious activity, which is a key aspect of ensuring a high level of cybersecurity.

An important component of developing and maintaining a security strategy is the systematic updating of all system components. Regular updating of system components will not only fix known vulnerabilities, but also keep the system up to date in accordance with modern cybersecurity requirements.

Interaction with the database is based on the principle of using parameterized queries, which is a significant protection against SQL injections. This approach will effectively limit the ability to execute unexpected commands through the data entered, minimizing the risks associated with deliberate attempts to compromise the integrity of the database.

This will allow us to effectively counteract massive hacking attempts, ensuring stable and uninterrupted operation of the system even in the event of aggressive external attacks.

This comprehensive approach to security guarantees a high level of security and availability of services provided by the system. As the system evolves, its security level will be predictably and comprehensively improved.

6. Virtual reality in agricultural education

Today, a steady trend has become apparent: progressive agricultural enterprises and organizations use innovative technologies, which require comprehensive specialized training to successfully master. One of the most effective ways to acquire skills is through simulations or specially equipped training centers. However, such training methods are currently expensive and usually inconvenient for students due to their geographical distribution.

In addition, internships in real simulators or specially equipped areas are not always safe for novice students [25]. The following risks exist in the training of specialists, in particular:

- students may inadvertently cause damage to some equipment;
- create an emergency situation by improper use of the devices;
- to be injured personally;
- cause harm to their colleagues without experience in complying with safety rules.

All these risks are natural, reasonable, and quite real, because most students at the first stages of their studies are unqualified in the areas of knowledge they are trying to master. Therefore, when training on real-world simulators, it is necessary to constantly pay attention to the above problems.

Virtual training, which is gaining more and more popularity nowadays, particularly in the agricultural sector, largely solves the problem of employee training and provides a significant reduction in the cost of such training.

Using virtual reality and augmented virtual reality, it is possible to recreate various scenarios of human interaction with potentially dangerous machines in a fairly realistic manner, and to do so in a game mode. In a game atmosphere familiar to modern youth, students have the opportunity to practice their skills and abilities automatically. After full mastery of the processes of controlling virtual units, it is much easier to apply these skills in practical activities with real equipment [26].

In particular, developments related to virtual reality are widely used in successfully solving the problems of training agricultural specialists in conditions close to the field. Applications that enable the acquisition and processing of data from sensors placed in the fields are also widely used, with the information transmitted in augmented reality format, so that the agronomist can immediately see

problem areas. Similarly, virtual reality can be used to identify areas of soil that are dehydrated or more moist than the field as a whole.

The software of virtual reality training applications should include a system for evaluating the success of tasks. Therefore, in such cases, the testing tasks developed by the authors of this paper [27] may be useful. These developments can become the basis of mathematical support not only for testing the level of students' training in virtual reality, but also in a broader field of tasks related to education in agriculture. In particular, using an artificial environment that exists in images but not in real life, it is already possible to test not only traditional classroom or distance exams but also plant protection products, determine what effect the selected products have on pests that cause plant diseases, etc.

7. Possible areas of study in the agricultural sector

The use of digital technologies can contribute to the productive functioning and efficiency of agri-food systems. The intensive use of digital technologies is already opening up new opportunities for the integration of small farms into digital agri-food systems. Moreover, this also applies to the involvement of farmers in training. In this case, blockchain technologies, the Internet of Things, virtual reality, artificial intelligence, etc. are used. The development of mobile technologies, remote sensing capabilities, and distributed data processing [28] is already expanding small farmers' access to information, finance, and training in the agricultural sector.

1. Even at the first stages of the educational process, the work of the authors of this paper can be successfully applied to automate the activities of educators during the admission campaign [29].
2. The creation and implementation of modern software in agriculture helps to educate farmers in the areas of enterprise resource planning, optimize procurement processes, crop protection, production, sales, etc.
3. The use of virtual reality simulators is gaining momentum and helps to improve the level of training for farmers and employees of large farms, in particular, in the management of drones, agrobots, training in the repair of agricultural machinery, etc.
4. The use of an intelligent yield forecasting system, in particular in the simulator mode, will allow agronomists of large farms and small farmers to improve their level in this area using artificial intelligence technologies and the application of decision theory methods.
5. The use of artificial intelligence technologies helps farmers and agricultural specialists assess the condition of fields, monitor each stage of the production cycle, receive and interpret data from satellites and drones, which certainly improves users' skills in this area and contributes to their educational level.
6. It is obvious that various combinations of these areas of study can be applied to specific farms and especially to modern specialized agricultural educational centers [30].
7. There will certainly be synergistic effects from the integrated application of these areas and additional opportunities for applying innovations in agricultural education that have not been previously envisaged.

This can be achieved, in particular, by creating powerful innovation and digital solutions ecosystems in large agricultural corporations. That is, a set of organizational, structural and functional institutions involved in educational processes and technologies in the agricultural sector.

8. Prospects for the use of artificial intelligence in agricultural education

Generative artificial intelligence, as a set of new advanced technologies, has emerged relatively recently and is currently developing rapidly. Some researchers consider this area to be the technology

of the future. Like any other new technology, AI has undoubtedly positive characteristics, but at the same time it carries obvious and hidden risks, and perhaps even dangers. Today, it is used in various areas of our lives: e-commerce, energy and utilities, telecommunications, automotive and transportation, airport chatbots, etc. The range of AI applications is constantly growing, and the elements of its presence in people's lives are steadily increasing.

It is clear that in such circumstances, there is a need for a systematic analysis of the impact of AI on society and identification of potential problems related to its development and further intellectualization. The negative impact of AI is largely due to its use to generate various kinds of content that will violate the principles of academic integrity. But this threat should not be exaggerated. It will certainly lead to the emergence of new trends in education that will be aimed at minimizing such violations. In addition, in the near future, technologies will appear to determine whether AI has been used to generate content with the corresponding consequences.

The main points of using artificial intelligence in agricultural training systems are shown in Figure 3. The diagram presented in Figure 3 does not reflect the sequence of use of the listed elements. In addition, the figure is not a demonstration of the priority of using artificial intelligence components in training systems.

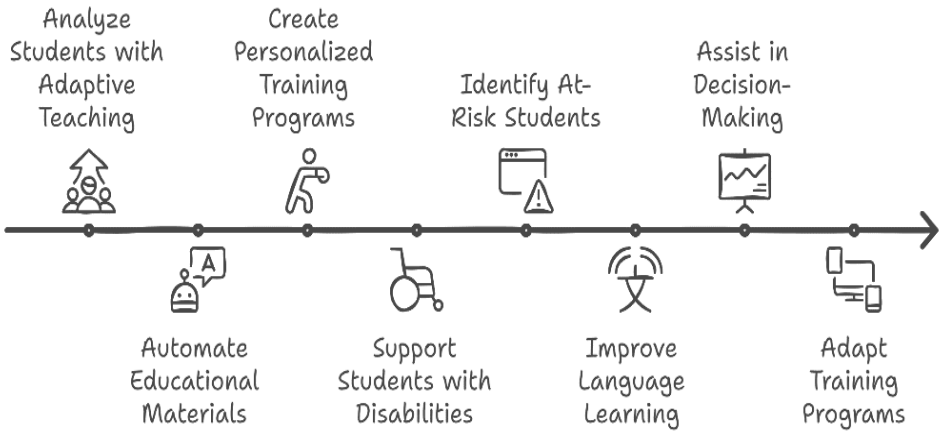

Figure 3: The use of AI in agricultural training systems.

The positive effect of the development, use, and implementation of AI technologies is much greater. Let's consider the main groups of tasks that can be solved with the help of AI. Let's denote this group of tasks by

$$T = \{\tau_1, \tau_2, \tau_3, \tau_4, \tau_5, \tau_6, \tau_7\}, \quad (8)$$

Let's list the main elements of the set (8):

τ_1 – generating express reviews of scientific papers at the initial stages of research in new scientific areas – this can help young researchers when writing articles and dissertations;

τ_2 – consulting assistance to teachers in the creation of teaching materials and in the generation of test questions, assignments for independent work, etc. during control measures;

τ_3 – help teachers analyze answers to open-ended questions when checking control measures and use AI to automatically evaluate students' work;

τ_4 – creating adaptive learning platforms for mass online courses with the ability to form individual trajectories and implement personalized learning, which analyzes student data, including

their academic progress, learning style, and other factors to create personalized learning materials and recommendations;

τ_5 – creating virtual assistants who can support students in their learning process;

τ_6 – assistance in automated construction of individual educational trajectories for students of the agricultural sector;

τ_7 – creating software for recognition and identification of text written by artificial intelligence, because the use of ChatGPT and other tools for writing text with the help of artificial intelligence violates the principles of academic integrity.

The main positive effects of the application of generative AI in many areas of education and scientific research are presented in Figure 4. Of course, all areas of agricultural education are also characterized by the indicated positive effects of the application of generative AI.

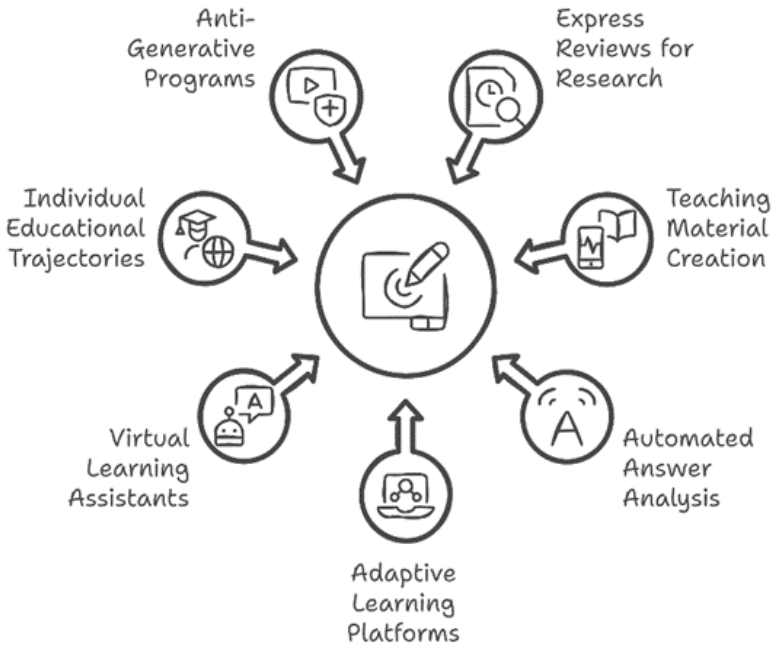

Figure 4: Positive effects of Generative AI in education and research.

9. Conclusions

The authors' analysis of technology development trends shows that new results periodically emerge that change our understanding of promising and rational directions of development of society and socio-economic systems. The technologies of AI are bringing us closer to the creation of full-fledged artificial intelligence systems. The development and coexistence of such systems and human civilization, the problems of expediency and security require interdisciplinary research at the intersection of philosophy, psychology, linguistics, ethics, and other sciences.

Declaration on Generative AI

The author(s) have not employed any Generative AI tools.

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