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RESEARCH ARTICLE

REVIEW

COMMENTARY

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REVIEW

Unleashing the potential of AI in modern healthcare: Machine learning algorithms and intelligent medical robots

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Abstract: Artificial intelligence (AI) is playing an increasingly vital role in transforming the medical field, particularly in areas like medical imaging, clinical decision-making, pathology, and minimally invasive surgery. The rapid growth of medical data and the continuous refinement of machine learning algorithms have propelled AI's integration into healthcare. This study explores the advancements and applications of AI, specifically machine learning algorithms and intelligent medical robots, in enhancing diagnostics, treatment, and healthcare delivery. A comprehensive review of current AI applications in healthcare, including its use in medical imaging, pathology, clinical decision-making, and robotic-assisted surgery, was conducted. AI technologies such as the Da Vinci Surgical Robot and machine learning-based diagnostic tools have significantly improved diagnostic accuracy and the precision of minimally invasive surgeries. AI-driven systems also contributed to better clinical decision support, faster recovery times for patients, and more accurate treatment plans. Overall, AI, through machine learning algorithms and intelligent medical robots, is revolutionizing healthcare by offering promising improvements in diagnostics, surgical precision, and patient care.

Keywords: computer artificial intelligence, machine learning algorithms, medical robots, AI algorithm

1 Introduction

Healthcare is currently undergoing a profound digital transformation with the potential to reshape various aspects of medical care [1]. This transformation has been driven by the immense pressure exerted on healthcare systems, infrastructure, supply chains, and personnel during the global COVID-19 pandemic. In response to these challenges, healthcare stakeholders have rapidly adopted and integrated digital technologies [2, 3]. Significant foundational changes have emerged in the healthcare sector since the pandemic, notably the increased involvement of patients in healthcare decision-making processes due to the growing acceptance of virtual healthcare systems and digital innovations [4]. However, notable challenges remain, and devising effective strategies to overcome them is crucial for shaping the future of healthcare. Patients and their experiences play a central role in driving innovation within the healthcare industry, with a strong focus on enhancing physician-patient interactions and ensuring the availability of patient-centered services globally [5]. The deployment of advanced digital devices has become essential to improving customer satisfaction, enabling features such as health tracking, remote monitoring, and better medication adherence [6]. These capabilities are particularly valuable during the post-hospitalization period, where digital health platforms offer continued care and monitoring. Despite these advancements, patients are understandably cautious about sharing their confidential data. Therefore, healthcare organizations (HCOs) must prioritize building and maintaining trust by emphasizing transparency, empathy, and reliability in their services to ensure patient confidence in these digital systems [6].

The healthcare field is undergoing a significant transformation driven by advancements in biomedical science. Key technologies at the forefront of this shift include genomics, digital medicine, artificial intelligence (AI), and machine learning (ML). These innovations are introducing novel technologies that demand a new type of workforce and updated standards of practice. Along with other advancements such as biometrics, tissue engineering, and developments in the vaccine industry, these technologies have the potential to enhance and revolutionize

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COMMENTARY

Aspects of information and spiritual similarity of real and virtual spaces

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Abstract: The results of numerous studies demonstrate the possibility of using the same approaches to studying real and virtual space in the context of their spatial perception. The study of virtual space can be carried out using the same parameters as physical space, and they should be considered equivalent. Virtual space is only one of the strategies for information copying of real space, the result of an irresistible human need to expand the horizons of research. Virtual space does not pose any threat to reality if we interpret the virtual environment as a transformation of the real environment, a new way of studying the mutual penetration of the virtual and real worlds. Learning to navigate in virtual space leads to safer life in real space.

Keywords: spatial perception, virtual environment, information field

1 Introduction

The spatial location of objects, the layout of the environment, and the boundaries of real and virtual environments are perceived in the same way. These processes are supported by a network of brain regions, including the hippocampus, retrosplenial cortex, striatum, and entorhinal cortex, to form representations of the environment and successfully navigate it [1,2]. Studies have shown that similar neural networks are active even during navigation in virtual environments [3]. The data suggest that in the spatial domain, the same neural architecture is involved in the perception of real and virtual space.

Research has also shown that virtual experience is an effective tool for shaping human behavior in response to social, stressful, and potentially dangerous situations. Research has confirmed the similarity of neural systems and mechanisms in real and virtual environments using neural imaging, electroencephalogram, and electrophysiology. The hippocampus plays a critical role in spatial perception and contains a network of neurons dedicated to encoding space [2]. Similar neural networks in the hippocampus are also active during spatial perception of a virtual environment [3].

Spatial navigation is assessed using virtual environments. It is divided into two types of navigation strategies: allocentric and egocentric. Allocentric navigation describes how cues in the environment relate to each other (map). Egocentric navigation describes how cues in the environment relate to the individual (set of directions). The hippocampus and surrounding medial temporal regions of the brain are involved in the formation of allocentric representations of space. The caudate nucleus and other striatal regions are required for the formation of egocentric representations of space. In humans, similar regions are active during navigation in real environments. Regardless of whether spatial navigation was performed using simple visual inputs (computer screen and joystick for movement) or using more enriched body movements (treadmill and VR headset), the neural networks underlying spatial movement were similar.

In all experiments that included both real and virtual environments, no evidence of differences in the formation of associative dynamic sequence spatial-temporal cognitive maps, navigation was found on spatial abilities. Spatial perceptions were well transferred between real and virtual experiences [4].

2 Information similarity of real and virtual space

Human interactions with the real and virtual environment have an informational status. By exploring the spatial relationships between real and virtual experience, we begin to study how identical the spatial perception of the virtual environment is to the real environment. Objects of

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RESEARCH ARTICLE

Formation of reflexive generative A.I. with ethical measures of use

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Abstract: The application of reflexive generative AI in the social sphere will improve the quality of life of individuals and society. Its commercial application will require compliance with ethical standard measures to ensure that its use does not cause harm. The development, implementation and use of an ethical standard for the use of reflexive generative AI will increase the safety of its use. The ethical use of generative AI by individuals should be automatically regulated by it. The reflection of generative AI is implemented by the AGI multilogic and ensures the validity of content generation.

Keywords: reflexive generative AI, ethical measures, content generation validity

1 Introduction

Generative AI (GenAI) is a technology that generates text, images, audio, video, code or other content based on algorithms, models or rules. The distinctive features of GenAI are its intelligence, creativity and its capabilities in these areas, so AI is likely to play a key role as an expert assistant that improves the efficiency and productivity of employees. Therefore, GenAI can be expected to become the main driver of the global economy, industry, medicine and other fields of activity.

Generative AI uses a computational process known as deep learning to analyze patterns in large data sets, then replicates it to create new data that appears human-generated. It does this using neural networks, a type of machine learning process that is similar to how the human brain processes, interprets, and learns from information over time. Generative AI models become more complex over time. The more and better the data a model is trained on, the more compelling its results. Generative AI has exploded in popularity thanks to the emergence of OpenAI models ChatGPT and DALL-E, which provide accessible AI tools to consumers. Google, Microsoft, Amazon, and Meta have all launched their own generative AI tools to capitalize on the technology's rapid adoption. Google is integrating generative AI into search with AI Overviews. Microsoft plans to embed generative AI even deeper into its PCs. Apple will introduce Apple Intelligence, a blend of proprietary AI models and OpenAI technology, in iOS 18, iPadOS 18, and macOS Sequoia later this year.

Generative AI models typically rely on the user to input a prompt that guides them to create the desired output, whether it's text, an image, a video, or a piece of music ChatGPT: An AI language model developed by OpenAI that can answer questions and generate human-like responses from text prompts. DALL-E 3: Another AI model from OpenAI that can create images and illustrations from text prompts. DALL•E 3 understands a lot of nuance and detail, making it easy to translate ideas into accurate images.

Gemini is a generative AI chatbot from Google and a competitor to ChatGPT. It's trained on the large language model PaLM and can answer questions and generate text from prompts.

Claude 3.5: Anthropic's Claude AI model offers a 200,000 token context window. Midjourney: Developed by San Francisco-based research lab Midjourney Inc., this AI model interprets text cues to generate images and illustrations, similar to DALL-E.

GitHub Copilot: An AI-powered coding tool that offers code completion suggestions in Visual Studio, Neovim, and JetBrains.

Llama 3: The open-source Meta large language model can be used to create conversational AI models for chatbots and virtual assistants, similar to GPT-4.

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RESEARCH ARTICLE

Modeling & optimization of Ti6Al4V turning for sustainable shearing considering rake angle

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Abstract: Titanium alloys, such as Ti6Al4V, have become increasingly prevalent in aerospace and biomedical industries owing to their exceptional mechanical properties and corrosion resistance. However, the machining of these alloys presents significant challenges including high tool wear, poor surface finish, and low productivity. This study focused on enhancing the machinability of Ti6Al4V during CNC turning using the Taguchi optimization method. This approach aims to identify the optimal cutting parameters that minimize the surface roughness, flank wear, and crater wear, thereby improving the overall machining performance. This study systematically investigated the influence of various cutting parameters on machining outcomes. The experimental results demonstrate that the Taguchi method effectively determines the optimal process parameters, leading to a significant reduction in surface roughness and tool wear. These findings highlight the potential of the Taguchi optimization technique for achieving improved machinability and sustainability in the machining of Ti6Al4V.

Keywords: Ti6Al4V, Taguchi optimization, rake angle, machinability

1 Introduction

Titanium alloys have emerged as indispensable materials in a wide array of industries because of their exceptional strength-to-weight ratio, remarkable corrosion resistance, and excellent biocompatibility. Among these alloys, Ti6Al4V, characterized by its superior mechanical properties and widespread availability, is a preferred choice for demanding applications in the aerospace, biomedical, and chemical processing sectors [1, 2]. Its high strength, even at elevated temperatures, coupled with its resistance to fatigue and creep, make it particularly suitable for components subjected to extreme conditions [3–5]. Despite its numerous advantages, Ti6Al4V presents significant machining challenges owing to its inherent properties. Its low thermal conductivity hinders efficient heat dissipation during machining, leading to elevated temperatures at the tool-workpiece interface [6, 7]. This localized heat buildup accelerates tool wear, compromising surface integrity and overall machining efficiency [8–10]. Moreover, the high chemical reactivity of titanium promotes adhesion and diffusion between the tool and workpiece materials, further exacerbating tool wear and resulting in poor surface finish. The formation of a hard and brittle surface layer, often referred to as the white layer, adds another layer of complexity to the machining process [11–13].

The challenges associated with machining Ti6Al4V necessitate careful consideration and optimization of various cutting parameters to achieve the desired machining outcomes. Traditional machining optimization methods, which often rely on trial-and-error approaches, are time consuming, costly, and often yield suboptimal results [14–16]. To address these limitations, the Taguchi method, a statistical experimental design technique, has gained significant traction in the optimization of manufacturing processes. Developed by Genichi Taguchi, the Taguchi method emphasizes a systematic and efficient approach to experimental design, enabling engineers to evaluate the influence of multiple parameters and their interactions with a reduced number of experimental runs. Unlike traditional full-factorial experiments, which require a large number of experiments, the Taguchi method employs orthogonal arrays, thereby significantly reducing the experimental burden without compromising the statistical significance of the results [17–20].

The Taguchi method revolves around the concept of signal-to-noise (S/N) ratio, a measure of robustness that quantifies the desired output characteristics relative to the noise factors. By maximizing the S/N ratio, the process becomes less sensitive to uncontrollable variations,

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RESEARCH ARTICLE

Self-learning AI in Educational Research and Other Fields

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Abstract: There are several areas where self-learning AI is actively used. Machine learning and deep learning allow you to identify patterns and improve performance. Algorithms such as neural networks can adapt and improve based on experience. Self-learning GPTs are used to dialogue with humans. Computer vision recognizes and classifies images. Recommender systems analyze user preferences and offer personalized solutions. Adaptive robotic industrial control systems can optimize processes by adapting to changing conditions and data. Self-learning intelligent systems help detect and respond to new threats and attacks by analyzing network traffic and user behavior. These technologies continue to evolve, opening up new research opportunities for students in the field of education. Self-learning AI helps programs learn, draw conclusions, and use them in the future. Programming languages do not consider algorithms as data. Programs do not have access to themselves. To learn, you need to change, and for this you need to have access to your own code. Then self-learning becomes possible. By generating the logic of self-learning algorithms, they can improve the program, it becomes different from its source code, and these changes must be saved. The interpreter of the algorithm improves the intelligence of the program, and it becomes the author of optimal solutions. The programming language of self-learning algorithms Author allows students to form the logic of self-learning algorithms to create intelligent systems that can help them in research activities. These systems are able to independently improve their skills and accuracy without explicit programming for each new type of task.

Keywords: Author programming language, intelligent self-learning program, research activity

1 Introduction to self-learning algorithms in the Author language

The file with the code "*.txt" has its duplicate "*.code". They form a module. When loading a module, the interpreter selects the file written later from the pair, the source code always remains untouched, and all changes that have occurred will be visible to the programmer in the duplicate file. The startup module must have an entry point (main) and to run it, you need to drag the file with the mouse to "author.exe". Any module can request additional loading of other modules (#include <me.txt>). Also, modules can be loaded and unloaded during code execution using the include("me.txt") and uninclude("me.txt") commands. Upon completion of the algorithm, the interpreter unloads the startup module. Each module has a counter for the number of modules that requested it, and if zero is reached, the module unloads its code into the duplicate file. The duplicate file of the module is rewritten only when at least one change has occurred in it (the module) or there was no duplicate at all. Thus, you can register the connection of modules as you wish, the module will always be in memory in one copy. You cannot connect yourself.

The module contains many functions. In the files, the program is presented as text. But when loading, the code is converted and developed to a dynamic structure of the algorithm scheme. For each function, a flow graph is created and the program gets access to it. When unloading the module, the algorithm scheme is converted back to program text. Variables in the language are not bound to a type, they do not have to be declared. A variable is also created when it is used in a construction for recording (a=0;). The value of any variable can have the following type: void, int, float, double, digit, char, string, interval, vector (set), set (unique set), map (associative array), program (algorithm tree), function (algorithm diagram), graf, module. When accessing for reading from an unknown variable, the "void" type is returned. The language also has pointers, they are organized as a string with data for accessing a variable. A variable can contain a pointer to itself (p=&p;p=****p;).

The language can use a special operand “#”. It returns the “void” type and serves as a symbolic designation of a hidden block, which, like any other operand, can be replaced with a tree operator structure of any complexity. When the “void” value gets into the condition of a ternary operator, the interpreter, each time, at the moment of execution, is randomly determined between true and false. When a value of the “void” type gets into the condition, the current execution point of the algorithm, at this moment, is divided into two. One goes by truth, the other by false. In further interpretation, as necessary, the entire memory map is divided into two.

The division of the execution point can be done with a special function “rozpad()”. It accepts multiple values and returns each of them at its execution point. Thus, the expressions “if(#);” and “if(rozpad({1,0}));” are similar. The expression “n=rozpad({1,2,3})+rozpad({10,150});” will cause a split into six processes, with different values of the variable “n”: 11, 12, 13, 151, 152 and 153. To randomly decide between all the process variants, you need to call the function “define();”. In this way, you can reduce all the execution points to one.

The Author language allows storing ambiguous values in any variable. Thus, algorithms written in this language may at any time encounter ambiguity in the process of solving the assigned task. The operand “#” returns the value “void”. When it gets into a conditional branching structure, which any cycle consists of, the execution point of the algorithm is divided into two. One goes along the truth branch, the other along the lie branch. Each execution point has its own memory map, that is, relative to one interpretation position, all variables contain single-valued values. Thus, after executing the first line of the program, the process is divided into two. They both continue to execute the same program, but with different values of the variable “m”. Then each process is divided into two more. One pair goes through the array reversal command, and the other does not. Then all processes issue a report to their common array.

When you have to make a choice and choose one of the alternatives, you need to have one, clearly formulated criterion. Here is a universal and simple criterion. To indicate in the algorithm the need to select one version of the process, with its data, the language has a built-in function/command “define()”. It selects one execution point from the existing set at the time of its execution. How it works. The current process reaches the command “define()” and stops. Another, not stopped, process from the list of parallel processes becomes active. When all the processes in the list become stopped, this means that it is time to make a choice of one of them. One execution point from the list is selected, and all other processes are closed. The selected process is launched for further execution of the algorithm. Thus, regardless of the order of processing parallel processes, after executing the command “define()” only one execution point remains, objectively, guaranteed, with its own version of data.

In the Author language, there are data types “graf” and “program”. A graph is a set of nodes and links between them. For the “graf” type, a node exists only if it has at least one link. Each link has two node numbers, the corresponding value of the presence of input arrows and the name of the link. In addition to links between nodes, in a universal graph, there is also a link of a node with a marker. A marker is a text string. Each link with a marker has one node number, a link name and a marker name. There are also logical values about the presence of an input arrow in a node and in a marker. To create a variable of the “graf” type, you need to use the type casting operator. Next, we set the graph itself with a shape similar to an open envelope. The “G.getMARKER(0,#,#,0,#)” method searches among the links of a node with a marker according to the specified mask and returns an array of found elements. Each element is an array with the data requested in the mask. The search mask must contain at least one unknown link detail, which is indicated by the “#” symbol. In the Author language, the “#” symbol returns a “void” value, which can be obtained, for example, from a function without “return”. The array method “.export()” will convert nested arrays to a string. The “trace()” function prints a string to the screen. The graph method “G.getNET(4,#,#,#,#)” searches for connections between graph nodes taking into account the symmetry of the search and works similarly to searching for connections with markers.

To clearly demonstrate the capabilities of the fundamental type “program”, the following example. The function algorithm line can specify the terminal branch of recursion. Then the variables can access the function in which it is located. Then the variables receive a unique identifier of the nodes in the (block) of the algorithm scheme, into which the function has turned at the time of execution. The last node is above the zero node. Next, we get copies of the command, which is in the last node of the algorithm scheme. Actually, the “command” is an object of the "program" type. It is a tree of operators and function calls with variables and constants. Any command can be either converted to text or executed. Using a method like "command.getSub({})" you can copy a branch from a tree by specifying an access path, in this case the entire tree will be copied. The "PROGRAM()" function converts a program text line to the "program" type.

2 Approaches and methods for writing intelligent self-learning programs

Creating self-learning programs requires a combination of theoretical knowledge and practical skills. It is important to choose the right approaches and methods depending on the specific task, available data and project goals.

2.1 Methods and techniques

(1) Data Preprocessing: Involves data cleaning, normalization, encoding categorical variables, and other steps to prepare the data for training.

(2) Feature Selection: The process of choosing the most informative features to train a model with, which can improve performance and reduce computational cost.

(3) Cross Validation: A method of assessing the quality of a model that involves splitting the data into training and test sets to test its generalization abilities.

(4) Regularization: Techniques such as L1 and L2 regularization are applied to prevent the model from overfitting by adding penalties for the complexity of the model.

(5) Hyperparameter Tuning: Optimizing the parameters of the model that are not trained on the data using methods such as Grid Search or Random Search.

(6) Ensemble Methods: Combining multiple models to improve overall performance. Examples include Bagging (e.g. Random Forest) and Boosting (e.g. AdaBoost, Gradient Boosting).

2.2 Intelligent self-learning programs with functional dynamic combinatorics

Intelligent self-learning programs with functional dynamic combinatorics is an interesting and complex topic that crosses several fields, including machine learning, combinatorics, and dynamic systems. Let's consider the main aspects:

(1) Self-learning programs: These are systems that can improve their performance based on experience. They use algorithms to analyze data, identify patterns, and adapt to new conditions.

(2) Functional dynamic combinatorics: This method refers to the study of combinations and permutations of objects depending on dynamic changes in the problem conditions. This may involve the use of different combinatorial structures and methods to solve problems that change over time.

(3) Optimization: Self-learning programs can use combinatorial methods to find optimal solutions in complex problems such as routing, scheduling, resource allocation, and others.

(4) Strategies: In problems with changing rules or conditions, such programs can adapt and find new strategies based on previous experience.

(5) Data Analysis: In data analysis tasks, dynamic combinatorics can be used to create models that can adapt to new data and identify new relationships.

(6) Algorithms and Technologies: Various algorithms can be used to implement such programs, including genetic algorithms, decision tree algorithms, neural networks, and other learning methods. Another important aspect is the use of combinatorial optimizations, such as dynamic programming.

(7) Future: With the development of technology and the increase in data volume, self-learning programs using dynamic combinatorics can find new applications in various fields, such as education, economics, medicine, robotics, and others.

2.3 Advantages of intelligent self-learning programs

Intelligent self-learning programs have a number of advantages that make them particularly attractive for use in various fields. Here are some of the main advantages: Intelligent self-learning programs have a number of advantages that make them particularly attractive for use in various fields. Here are some of the main advantages:

(1) Process Automation: Self-learning programs can automate routine tasks, reducing the need for human intervention and reducing the likelihood of errors, which improves the overall efficiency of processes.

(2) Adaptability: These systems are able to adapt to changes in data over time. They can analyze new data and adjust their models, allowing them to stay relevant without the need for manual updates.

(3) Big Data Processing: Intelligent programs can process and analyze large volumes of data, which allows them to extract useful insights and identify hidden patterns that may not be obvious during manual analysis.

(4) Improving Accuracy: Machine learning systems can continually improve their accuracy as they receive new data. This makes them especially useful in areas where high accuracy is critical, such as medicine, finance, and security.

(5) Personalization: Self-learning programs can use user data to create personalized recommendations and solutions, which increases customer satisfaction and improves the user experience.

(6) Predictive capabilities: Such programs can predict future events based on historical data. This is especially useful in areas such as demand forecasting, financial analysis, and risk assessment.

(7) Innovation and new opportunities: Using intelligent self-learning programs can lead to the development of new products and services, as well as the improvement of existing ones, opening up new business opportunities.

(8) Cost reduction: Automation of processes and increased accuracy can lead to lower labor and resource costs, making the business more efficient.

(9) Improved customer service: Intelligent systems can be used to create chatbots and virtual assistants that provide 24/7 customer support and quickly resolve customer issues.

(10) Anomaly Detection: Self-learning programs can effectively detect anomalies and deviations in data, which is useful for detecting fraud, cyber threats, and other abnormal events.

The fundamental advantage of intelligent self-learning programs is the ability to visually edit your own algorithm. This ability is necessary and sufficient for writing self-learning programs. As a result, intelligent self-learning programs open up new horizons for business, science, and technology, providing more effective and accurate solutions for a wide range of problems.

3 Improving the intelligent self-learning program for finding solutions in the language Author

Intelligent self-learning programs satisfy three conditions: 1) replication, the ability to reproduce and produce digital offspring; 2) variability, the ability to change and differentiate between digital scenarios; 3) improvement of digital offspring and scenarios.

It is possible to configure programs for self-improvement of self-learning using scientific data confirmed by practice [1]. The logic of self-learning is set by the developer in the schemes of program algorithms. The logic of self-learning operates by modifying algorithms and data in the direction of improving solutions.

The Author language interpreter integrates synergetic cognitive queries to subject knowledge ontologies, covering different AI strategies: 1) Directs interdisciplinary cognitive logic of working with algorithms according to the developer's criteria; 2) Determines the knowledge that should be in memory at any given moment; 3) Implements the process of forgettingineffective decisions.

Let's consider a self-learning intelligent program for marking and issuing effective solutions with prime numbers for a variety of areas of activity in the Author programming language. Based on the ability of the "Author" language, changes are made to the native code of programs by creating a repository of marked effective solutions within the program code in the range from 1 to 200 with activity area numbers inside the program code.

```
// prosto.txt
//. self-learning program for finding effective solutions
var isProsto(n){
        numbers of effective solutions m={2,3,5,7};
        if(n<0)return #;
        ok=0;
        if(n==0 || n==1)ok=1;
        for(i=0;i<m.size();++i){
                if(n==m[i]){ok=1;break;}
                if(n<m[i])break;
                }
        if(i==m.size()){
                u=m[i-1];
                oknew=0;
                do{
                        ++u;
                        uok=1;
                        for(i=0;i<m.size();++i)if(!(u%m[i])){uok=0;break;}
                        if(uok){
                                oknew=1;
                                m.push(u);
                                if(u==n)ok=1;
                                }
                        }while(n>u);
                if(oknew){
                        f=getFunction(getThisFunctionName());
                        pos=f.Root();
                        pos=f.Next(pos);
                        f.setComand(pos,"m="+m.export());
                        }}
        return ok;}
void main(){ok=isProsto(n=200); trace("Число "+n+(ok?"":" не")+" effective solution.");}
```

The task is to call the function “isProsto(n)” with a given number for analysis. Actually, the variable “m” contains our storage. To replace the command in the algorithm scheme, the function “f.setComand(pos,“m={solution 2, solution 3}”);” is used, which must be called from the function object. The first parameter must specify the identifier of the node with the command in the graph scheme of the algorithm, which (the command) should be replaced, and the second is the command object (the operator tree). The second parameter can also be a text string that will be implicitly transformed. In order to get the node identifier, we use the fact that the array/storage is on the first node from the beginning of the function algorithm. The function “f.Root()” will return the identifier of the first and last node of the scheme, so to speak, the node of the beginning of the end of the algorithm. From it (the node) you can go to, guaranteed, one, the first node. But moving up from the first and last node (“f.Up(pos)”) it is possible to get a set (an array of identifiers) of nodes, which end the algorithm. The point is that at the end of the algorithm there may be a conditional operator with a branch leading to the beginning of the end node.

After running the program, the function “isProsto(n)” was transformed. The Author language has the ability to use labels, which can be used to find the identifiers of the nodes corresponding to them in the algorithm scheme. The program needed to perform complex calculations that only needed to be done once, so as not to waste time on the same calculations every time the program was launched. The ability of the language to transform the script is used to solve this problem.

```
// one.txt
void main(){
        trace("Helloy World!!!");
        <label:10>
        if(1){
                x=1+1; // сложные вычисления
                f=getFunction(getThisFunctionName());
                pos=f.getLabel(10); // ищем метку
                pos=f.insertDown(pos);
                f.setCommand(pos,"x="+x);
                pos=f.Down(pos);
                command=f.getCommand(pos);
                command.setSub({0},PROGRAM("0"));
                f.setCommand(pos,command);}
        trace(x);
        getstring();}
```

Duplicate code from which the interpreter will take the program code after the first launch:

```
// one.code
void main(){
        trace("Helloy World!!!");
        <label:10>
        x=2;
        if(0){
                x=1+1;
                f=getFunction(getThisFunctionName());
                pos=f.getLabel(10);
                pos=f.insertDown(pos);
                f.setCommand(pos,"x="+x);
                pos=f.Down(pos);
                command=f.getCommand(pos);
                command.setSub({0},PROGRAM("0"));
                f.setCommand(pos,command);
                }
        trace(x);
        getstring();}// one.code
```

The language has a special system function "Spirit();", which deletes itself the first time it is executed. It takes the name of the function and arguments to it. The function will be called only once and no traces will remain of it.

```
// Spirit.txt
firstprocess(namef,n){
        x=100*(1+1);
        f=getFunction(namef);
        pos=f.getLabel(n);
        f.setCommand(pos,PROGRAM("k="+x));
        return 1;}
void main(){
        Spirit("firstprocess",getThisFunctionName(),10);
        <label:10>
        trace("k="+k);
        getstring();}
```

The program will display an effective solution and transform into a digital offspring with a new scenario. Self-training of the program in the process of implementing the user's request according to new scenarios increases its professionalism.

The program with the proposed algorithm schemes and self-learning logic provides safe recommendations and professional knowledge and skills to students in various combinations and an interdisciplinary range of activities based on ethical standards [2, 3].

Combining generative and algorithmic logic in the context of unsupervised artificial intelligence leads to powerful models that can generate new data and apply logical rules to process and analyze it. Combining generative and algorithmic logic can occur in the following ways:

(1) Using generative models to pre-process data: Generative models can be used to create synthetic data that can then be processed using algorithmic methods. This is especially useful in cases where real data is limited or unavailable.

(2) Algorithmic control of the generation process: Generative models can be guided by algorithmic methods that determine how and when to generate new data. This is useful in applications where the context or dynamics of a situation must be taken into account.

(3) Hybrid models: Developing models that use both generative approaches and algorithmic methods. For example, in the field of natural language processing, one can use generative models to generate text and then apply algorithmic approaches to analyze and structure that text.

(4) Code generation: Using generative models to create software code that can then be tested using algorithmic logic to find bugs or optimize.

(5) Data generation: Generative models can create data sets for algorithms that can then be used to improve predictions.

(6) Generate game levels based on gameplay logic, allowing for unique and effective levels that adhere to the game rules.

Generative models such as GANs (Generative Adversarial Networks) and VAEs (Variational Autoencoders) can create new data samples based on a training set. These models learn from structured data and can be used to generate images, text, music, and other forms of content.

Combining generative and algorithmic logic opens up new horizons in the development of

AI systems, allowing them to be more adaptive, creative, and effective in solving complex problems. This direction has great potential for further research and application in various fields such as art, science, economics, and technology.

Artificial intelligence can be taught to work by interacting with it here and now, observing its actions and giving it timely, detailed recommendations, which improves its ability to adapt and learn. Artificial intelligence can continue to self-learn even after a human stops giving feedback, using an AI model created based on the developer's data. This approach opens up new possibilities for creating self-learning and adaptive AI systems.

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4 Conclusion

Self-learning artificial intelligence (AI) is playing an increasingly important role in student research, providing them with new tools and opportunities for in-depth study and analysis of data. Here are some key aspects that are affected by the use of self-learning AI in educational and research processes:

(1) Data Analysis: Self-learning AI can process large amounts of data faster and more accurately than a human can manually. This allows learners to conduct deeper research, identify hidden patterns, and draw more informed conclusions.

(2) Personalized Learning: AI systems can adapt to the individual needs of the learner, offering personalized recommender systems that help students focus on areas for improvement, thereby improving learning efficiency.

(3) Modeling and Simulation: AI is used to create complex models and simulations that can be useful in a variety of fields such as physics, biology, economics, and social sciences. This gives learners the opportunity to experiment with different scenarios and explore their implications in a controlled environment.

(4) Natural Language Processing: AI can analyze and interpret large amounts of textual information, which is useful for conducting literature reviews and text mining in the humanities.

(5) Creative Projects: Self-learning AI can be used in creative projects such as generating musical compositions, creating visual art, or writing texts, expanding students' capabilities in the field of art and design.

(6) Automation of Routine Tasks: AI can automate many routine tasks such as data collection and pre-processing, allowing students to focus on more complex aspects of research.

(7) Ethics and Responsibility: Research activities using AI also raise important questions about ethics and responsibility, encouraging students to think critically and discuss the implications of AI in society.

Self-learning artificial intelligence systems in the field of robotic education are a promising direction that can significantly change the approach to learning. Key aspects of using such technologies:

(1) Adaptive Learning: Self-learning AI can adapt learning materials and teaching methods to the individual needs of each student. This allows for the creation of personalized educational programs that take into account the level of knowledge, learning speed, and preferences of students.

(2) Tutoring Robots: AI-powered robots can act as tutors, providing students with assistance in learning various subjects. They can assess students' progress and offer additional exercises or explanations on difficult topics.

(3) Interactive Learning Platforms: Platforms equipped with self-learning algorithms can analyze students' interactions with materials and adapt the content in real time to improve learning outcomes. Robotic platforms such as LEGO Mindstorms or VEX Robotics can use AI to teach coding, engineering, and logical thinking skills.

(4) Assessment and Feedback: Self-learning systems can automate the assessment process, providing students with instant feedback and recommendations on how to improve their skills.

(5) Social Skills Development: AI robots can be used to develop social and communication skills, especially in children with special educational needs. They can engage students in interactions with others.

The use of self-learning AI in robotic education opens up new possibilities for more effective and personalized learning, helping students develop both academic and practical skills (Figure 1).

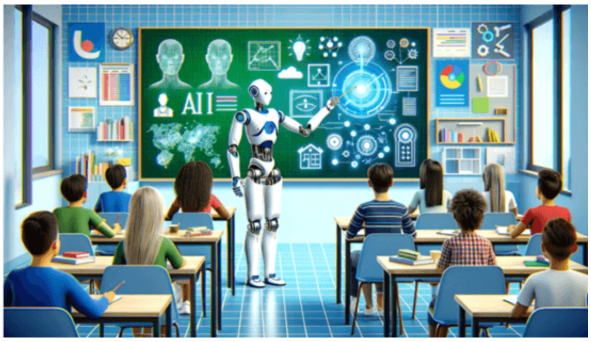

Figure 1 Robotic teacher with self-learning AI

The use of self-learning AI for educational and research purposes opens up new horizons for students, allowing them to develop multi-inter-trans research skills that will be in demand in the future [4–8]. However, it is important to remember the ethical aspects and the need to control the results obtained using AI [9–20]. Based on self-learning AI, it is possible to develop smart wearable technologies as well as intelligent collaborative technologies [21, 22].

Conflicts of interest

The author declares that there is no conflict of interest.

References

[1] Bryndin E. Creation of Multi-purpose Intelligent Multimodal Self-Organizing Safe Robotic Ensembles Agents with AGI and cognitive control. COJ Robotics & Artificial Intelligence (COJRA). 2024, 3(5): 1-10.

[2] Bryndin E. Formation of reflexive generative A.I. with ethical measures of use. Research on Intelligent Manufacturing and Assembly. 2024, 3(1): 109-117.
https://doi.org/10.25082/rima.2024.01.003

[3] Saxena AK. Society and the Machine: Navigating Ethics in the Age of Artificial Intelligence. 2024, 127.
https://www.amazon.com

[4] Furze L. Practical AI Strategies: Engaging with Generative AI in Education. Amba Press. 2024, 198.

[5] Mastrapasqua F. Natural technologies for sustainability. The Project Repository Journal. 2021, 10(1): 128-132.
https://doi.org/10.54050/prj10128132

[6] Bowen JA, Watson CE. Teaching with AI: A Practical Guide to a New Era of Human Learning. Johns Hopkins University Press. 2024, 280.

[7] The Future of AI in Education: Personalized Learning and Beyond. 2024.
https://www.hp.com/in-en/shop/tech-takes/post/ai-in-education

[8] Oyebola Olusola Ayeni, Nancy Mohd Al Hamad, Onyebuchi Nneamaka Chisom, et al. AI in education: A review of personalized learning and educational technology. GSC Advanced Research and Reviews. 2024, 18(2): 261-271.
https://doi.org/10.30574/gscarr.2024.18.2.0062

[9] Makridakis S. The forthcoming Artificial Intelligence (AI) revolution: Its impact on society and firms. Futures. 2017, 90: 46-60.
https://doi.org/10.1016/j.futures.2017.03.006

[10] Nyashenko S, Zvereva A, Golubtsova E, et al. The impact of digitalization on the client-oriented approach in the provision of public services to business entities. IOP Conference Series: Materials Science and Engineering. 2020, 940: 012061.
https://doi.org/10.1088/1757-899x/940/1/012061

[11] Green E, Singh D, Chia R, et al. AI ethics and higher education: good practice and guidance for educators, learners, and institutions. Published online 2022.
https://doi.org/10.58863/20.500.12424/4146302

[12] Kalna F, Belangour A. A Meta-model for Diverse Data Sources in Business Intelligence. American Journal of Embedded Systems and Applications. 2019, 7(1): 1. https://doi.org/10.11648/j.ajesa.20190701.11

[13] Babulak E. Third Millennium Life Saving Smart Cyberspace Driven by AI and Robotics. COJ Robotics & Artificial Intelligence. 2021, 1(4).

[14] Farooq MS, Tahseen R, Omer U. Ethical Guidelines for Artificial Intelligence: A Systematic Literature Review. VFAST Transactions on Software Engineering. 2021, 9(3): 33-47. https://doi.org/10.21015/vtse.v9i3.701

[15] Leonov V A, Kashtanova E V, Lobacheva A S. Ethical aspects of artificial intelligence use in social spheres and management environment. European Proceedings of Social and Behavioural Sciences. 2021, 106: 989-998. https://doi.org/10.15405/epsbs.2021.04.02.118

[16] Hallamaa J, Kalliokoski T. AI Ethics as Applied Ethics. Frontiers in Computer Science. 2022, 4. https://doi.org/10.3389/fcomp.2022.776837

[17] Riczu Zs. Recommendations on the Ethical Aspects of Artificial Intelligence, with an Outlook on the World of Work. Journal of Digital Technologies and Law. 2023, 1(2): 498-519. https://doi.org/10.21202/jdtl.2023.21

[18] Shelton K, Lanier D. The Promises and Perils of AI in Education: Ethics and Equity Have Entered the Chat. Lanier Learning. 2024, 189.

[19] Singh G, Thakur A. AI in Education. The Ethical Frontier of AI and Data Analysis. Published online April 12, 2024: 18-38. https://doi.org/10.4018/979-8-3693-2964-1.ch002

[20] Pan K. Ethics in the Age of AI: Research of the Intersection of Technology, Morality, and Society. Lecture Notes in Education Psychology and Public Media. 2024, 40(1): 260-262. https://doi.org/10.54254/2753-7048/40/20240816

[21] Khristopher Y. (2024).Wearable tech: Fashion meets functionality in 2024. Android Headlines. https://www.androidheadlines.com

[22] Kazerani F. The Pulse of Progress: Smart Wearables and the Evolution of Cardiovascular Monitoring Technologies. International Journal of Research In Science & Engineering. 2024, (44): 30-36. https://doi.org/10.55529/ijrise.44.30.36

leading to improved quality and consistency [19, 21, 22]. The Taguchi method also incorporates analysis of variance, a statistical technique used to determine the relative significance of each parameter on the output response. In the context of CNC turning of Ti6Al4V, the Taguchi method can be effectively employed to optimize cutting parameters, such as cutting speed, feed rate, depth of cut, and rake angle [19, 23]. These parameters significantly influence machining performance, thereby affecting surface roughness, tool wear, and tool life. By systematically varying these parameters and analyzing their impact on the desired output characteristics, the Taguchi method enables the identification of optimal cutting conditions that minimize surface roughness, reduce tool wear, and maximize tool life [24, 25].

This study focuses on leveraging the Taguchi method to optimize the CNC turning process of Ti6Al4V to achieve improved surface integrity, reduced tool wear, and enhanced machining efficiency. This study investigates the influence of cutting speed, feed rate, depth of cut, and rake angle on surface roughness, flank wear, crater wear, and tool life. By employing orthogonal arrays, S/N ratio analysis, and ANOVA, this study aims to determine the optimal cutting parameters that yield the most favorable machining outcomes. The findings of this study will provide valuable insights for optimizing the CNC turning process of Ti6Al4V, contributing to enhanced machining efficiency, improved surface quality, reduced tool wear, and ultimately, more sustainable manufacturing practices. The optimized cutting parameters derived in this study can be readily implemented in industrial settings, leading to cost savings, reduced material waste, and improved product quality.

2 Material and methods

This study employed a systematic approach to optimize the CNC turning parameters of Ti6Al4V using the Taguchi method. This methodology encompasses material selection, parameter identification, experimental design, machining experiments, performance measurement, data analysis, and validation.

2.1 Material selection

The workpiece material used in this study was Ti6Al4V with dimensions of Ø 40 mm × 80 mm. Widely used Ti alloys are known for their exceptional mechanical properties and machinability. The chemical composition of the Ti6Al4V alloy used in this study is presented in Table 1.

Table 1 Chemical properties of Ti-6Al-4V

Contents	C	Fe	N	O	Al	V	H	Ti
wt. %	0.08	0.25	0.05	0.20	5.50-6.75	3.5-4.5	0.01	Balance

2.2 Parameter Identification

Four crucial cutting parameters with their levels were selected for optimization based on their significant influence on the machining performance of Ti6Al4V, as shown in Table 2.

Table 2 Process parameters with their levels

Sr. No.	Cutting Speed (Vc) (m/min)	Feed Rate (f) (mm/rev.)	Depth of Cut (d) (mm)	Rake Angle (α) (degree)
1	80	0.12	0.6	10
2	100	0.18	0.12	14
3	120	0.24	0.18	16
4	140	0.30	0.24	18
5	160	0.32	0.30	20

2.3 Experimental Design

An L25 orthogonal array, a statistical design matrix, was employed to efficiently evaluate the influence of the selected parameters on machining performance. This array allowed for the investigation of four factors, each at four levels, with only twenty-five experimental runs, significantly reducing the experimental burden compared to a full-factorial design. Table 3 presents the selected levels for each parameter and the corresponding L25 orthogonal array.

Table 3 L25 orthogonal array

Trial No.	Vc (m/min)	f (mm/rev.)	d (mm)	α (degree)
1	80	0.12	0.6	10
2	80	0.18	0.12	14
3	80	0.24	0.18	16
4	80	0.30	0.24	18
5	80	0.32	0.30	20
6	100	0.12	0.12	16
7	100	0.18	0.18	18
8	100	0.24	0.24	20
9	100	0.30	0.30	10
10	100	0.32	0.60	14
11	120	0.12	0.18	20
12	120	0.18	0.24	10
13	120	0.24	0.30	14
14	120	0.30	0.60	16
15	120	0.32	0.12	18
16	140	0.12	0.24	14
17	140	0.18	0.30	16
18	140	0.24	0.60	18
19	140	0.30	0.12	20
20	140	0.32	0.18	10
21	160	0.12	0.30	18
22	160	0.18	0.60	20
23	160	0.24	0.12	10
24	160	0.30	0.18	14
25	160	0.32	0.24	16

2.4 Machining Experiments

CNC turning experiments were conducted on an MTAB CNC 2-Axis lathe machine using DNMG110408 MP3 Walter-Tiger inserts. The experimental setup is shown in Figure 1. Each experimental run adhered to the predefined cutting parameters outlined in the L25 orthogonal array with a 15% concentrated water-miscible coolant. During each run, the following machining performance characteristics were meticulously measured, as listed in Table 4.

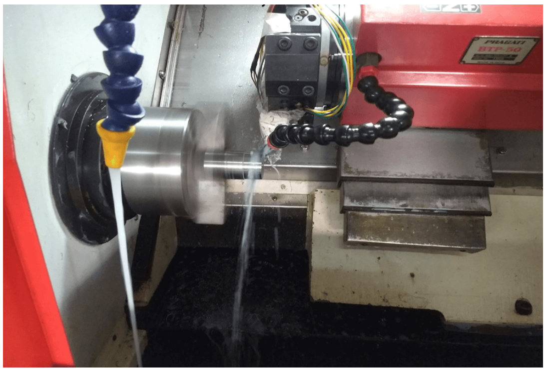

Figure 1 Experimental set up

2.5 Performance Measurements

Following each experimental run, the surface roughness of the machined workpiece was measured at three different locations and the average value was recorded. Tool-wear measurements, including flank wear and crater wear, were conducted using a toolmaker microscope equipped with a calibrated reticle.

3 Results and Discussion

3.1 Data analysis

The collected experimental data were systematically analyzed using the Taguchi method. The signal-to-noise (S/N) ratio, a measure of robustness, was calculated for each response characteristic (surface roughness, flank wear, and crater wear) using appropriate S/N ratio

Table 4 Performance of experimental trials

Trial No.	Flank Wear (μm)	Crater Wear (μm)	Ra (μm)
1	740	25.1	0.535
2	214	16.4	0.716
3	129	22.2	1.542
4	266	16.4	1.02
5	253	18	4.918
6	286	23.2	1.162
7	187	17.9	1.137
8	568	27.8	3.171
9	173	16	0.327
10	283	22.5	0.494
11	108	17	0.957
12	205	15.1	0.523
13	88.1	16.4	0.59
14	253	20.7	0.91
15	508	25.2	0.671
16	198	26.1	0.789
17	171	15.1	0.636
18	333	15.5	0.787
19	752	23.4	2.962
20	113	14	1.707
21	487	14	0.915
22	70.4	16	2.045
23	60.3	11.9	0.494
24	67.5	18.7	0.563
25	284	15.9	0.74

formulas, depending on the desired output characteristic (smaller-the-better). (refer Table 5).

Table 5 S to N ratios of experimental results

Trial No.	Flank Wear	Crater Wear	Ra
1	-57.3846	-27.9935	5.4329
2	-46.6083	-24.2969	2.9017
3	-42.2118	-26.9271	-3.7617
4	-48.4976	-24.2969	-0.1720
5	-48.0624	-25.1055	-13.8358
6	-49.1273	-27.3098	-1.3041
7	-45.4368	-25.0571	-1.1152
8	-55.0870	-28.8809	-10.0239
9	-44.7609	-24.0824	9.7090
10	-49.0357	-27.0437	6.1255
11	-40.6685	-24.6090	0.3818
12	-46.2351	-23.5795	5.6300
13	-38.8995	-24.2969	4.5830
14	-48.0624	-26.3194	0.8192
15	-54.1173	-28.0280	3.4655
16	-45.9333	-28.3328	2.0585
17	-44.6599	-23.5795	3.9309
18	-50.4489	-23.8066	2.0805
19	-57.5244	-27.3843	-9.4317
20	-41.0616	-22.9226	-4.6447
21	-53.7506	-22.9226	0.7716
22	-36.9515	-24.0824	-6.2139
23	-35.6063	-21.5109	6.1255
24	-36.5861	-25.4368	4.9898
25	-49.0664	-24.0279	2.6154

3.2 Flank wear optimization

Table 6 presents the mean signal-to-noise (S/N) ratio response for flank wear obtained from Taguchi L25 orthogonal array experiments. A higher S/N ratio indicates a more desirable outcome, representing minimal deviation from the desired low-flank wear.

Figure 2 generated using Minitab 17 software, visually depicts the mean S/N ratios for flank wear across different levels of each control factor. The graph highlights the optimal parameter

Table 6 Mean S to N ratio response table for Flank wear

Process Parameters	Mean SN ratios					
	L 1	L 2	L 3	L 4	L 5	Rank
Vc (m/min)	-48.55	-48.69	-45.60	-47.93	-42.39	3
f (mm/rev.)	-49.37	-43.98	-44.45	-47.09	-48.27	4
d (mm)	-48.60	-41.19	-48.96	-46.03	-48.38	1
α (degree)	-45.01	-43.41	-46.63	-50.45	-47.66	2

combination that yielded the highest mean S/N ratio.

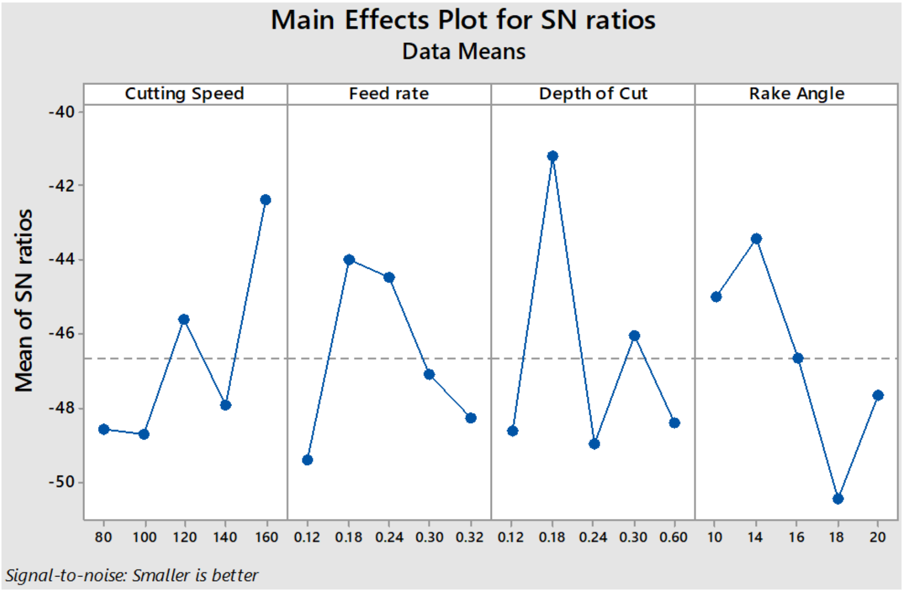

Figure 2 Mean S/N ratios for Flank wear

As is evident from Figure 2, the optimal parameter settings for minimizing flank wear are as follows:
(1) Cutting speed (Vc) = 160 m/min;
(2) (f): 0.18 mm/rev;
(3) Depth of cut (d): 0.18 mm;
(4) Rake angle (α): 14°.

These settings correspond to the highest point on the graph, indicating the most robust condition for minimizing flank wear. Furthermore, Table 6 reveals that the depth of cut exhibited the most significant influence on flank wear, achieving rank 1 across all levels. This ranking indicates that among the four investigated parameters, the DOC exerts the most substantial impact on flank wear. Consequently, maintaining a low DOC is crucial for minimizing flank wear during the CNC turning of Ti6Al4V.

3.3 Crater wear optimization

Table 7 Signal-to-noise ratio response plot of crater wear using Taguchi L25 orthogonal array experiments. Similar to the flank wear analysis, a higher S/N ratio indicated better results, indicating less deviation from crater wear in the area. Figure 3 shows that the mean S/N ratios for crater wear with different levels of each control factor are represented visually in the bar chart generated by the Minitab software. The chart shows the best parameter combination with respect to the highest mean S/N ratio.

As shown in Figure 2, the optimal parameter settings for minimizing crater wear are as follows:
(1) Cutting speed (Vc) = 160 m/min;
(2) (f): 0.18 mm/rev;
(3) Depth of cut (d): 0.3 mm;
(4) Rake angle (α) = 10 °.

The peak locations in our graph are the strongest conditions for minimal crater wear. Sub-

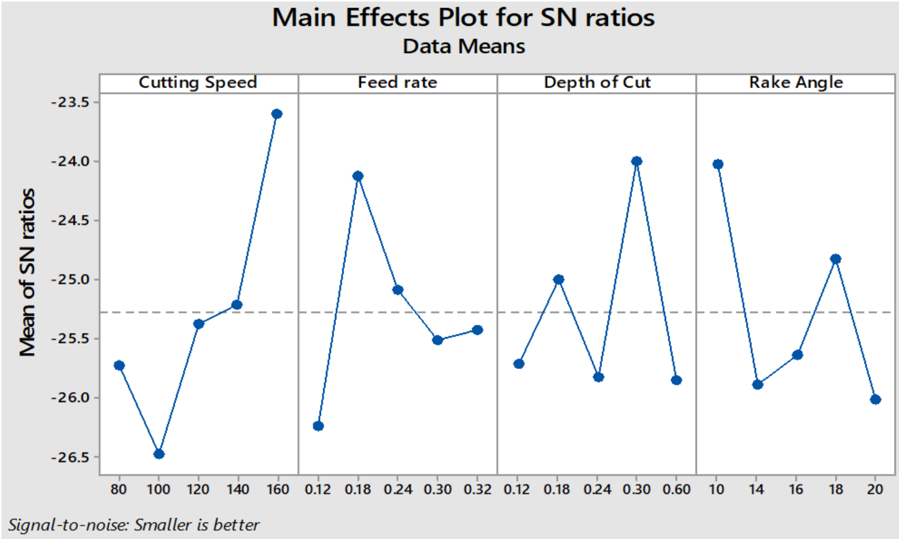

Figure 3 Mean S/N ratios for Crater wear

Table 7 Mean S to N ratio response table for Crater wear

Process Parameters	Mean SN ratios					
	L 1	L 2	L 1	L 4	L 1	Rank
Vc (m/min)	-25.72	-26.47	-25.37	-25.21	-23.60	1
f (mm/rev.)	-26.23	-24.12	-25.08	-25.50	-25.43	2
d (mm)	-25.71	-24.99	-25.82	-24.00	-25.85	4
α (degree)	-24.02	-25.88	-25.63	-24.82	-26.01	3

sequent analysis of Table 7 reveals that cutting speed is the dominant factor in crater wear, performing number one at all replication levels. This shows that of the four parameters examined, the cutting speed was by far and away, exerting a significant influence on crater wear. Consequently, the optimal cutting speed is key to minimizing crater wear in the CNC turning of Ti6Al4V.

3.4 Average Surface roughness value optimization

The resulting response table for the surface finish is presented for the obtained S to N ratio in Table 8.

Table 8 Mean S to N ratio response table for Ra

Process Parameters	Mean SN ratios					
	L 1	L 2	L 1	L 4	L 1	Rank
Vc (m/min)	-1.88696	0.67825	2.97588	-1.20131	1.65767	2
f (mm/rev.)	1.46812	1.02670	-0.19934	1.18287	-1.25481	3
d (mm)	0.35139	-0.82999	0.02157	1.03173	1.64884	4
α (degree)	4.45055	4.13169	0.45992	1.00608	-7.82470	1

From the observations in Figure 4, the rake angle is highly effective for the surface quality during the turning of Ti6Al4V. As shown in Figure 4, the optimal parameter settings for minimizing the average surface roughness values areas follows:

(1) Cutting speed (Vc): 120 m/min;
(2) (f): 0.3 mm/rev;
(3) Depth of cut (d): 0.6 mm;
(4) Rake angle (α) = 10 °.

As shown in Table 8, Rake angle 100 has a rank of 1 at all process parameter levels. Among the four process parameters, the rake angle affected the surface finish the most. Therefore, a lower value of the rake angle leads to a Better Surface finish; hence, it is subtractive.

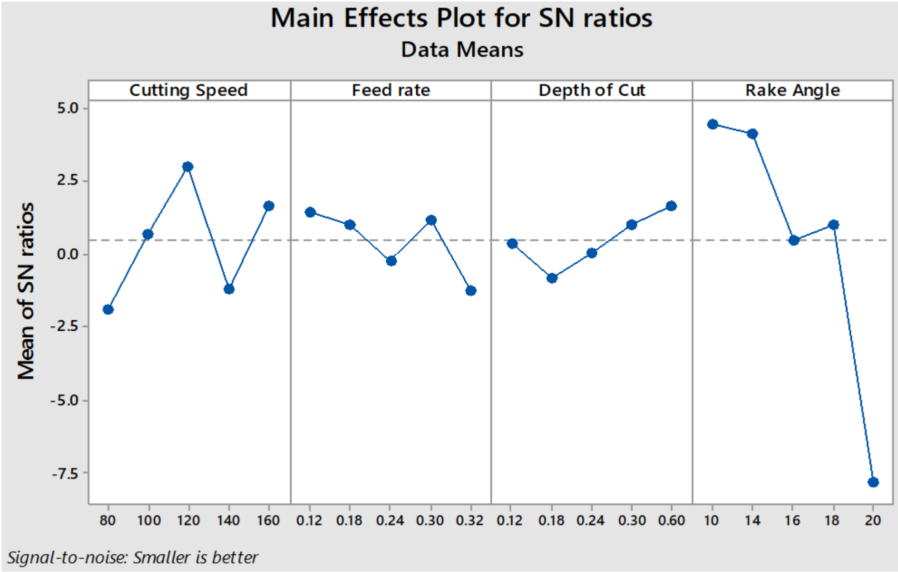

Figure 4 Mean S/N ratios for Ra

3.5 Validation

Confirmation experiments were conducted using the optimal cutting parameters predicted by the Taguchi method to validate its effectiveness in enhancing the machinability of a Ti alloy (Ti6Al4V). The results for the Surface Roughness, Flank wear, and crater wear are presented in Table 9, 10, and 11, respectively.

Table 9 Test result for surface roughness

	Initial process parameter	Optimal process parameters	
		Prediction	Experiment
Level	Vc1-f4-d4-α4	Vc2-f3-d3-α3	Vc2-f5-d1-α2
Surface roughness (μm)	1.02		0.494
S to N ratio (dB)	33.6969	26.015	29.3898
Improvement in S to N ratio (dB)		4.3071	
Percentage reduction of surface roughness		51.56%	

Table 10 Test result for Flank wear

	Initial process parameter	Optimal process parameters	
		Prediction	Experiment
Level	Vc1-f4-d4-α4	Vc5-f2-d2-α2	Vc5-f3-d2-α1
Flank wear (μm)	266		60.3
S to N ratio (dB)	-48.4976	19.0526	-35.6063
Improvement in S to N ratio (dB)		12.8913	
Percentage reduction in Flank wear		77.33%	

The confirmation experiments demonstrated a significant improvement in all three performance characteristics compared with the initial parameter settings. Specifically:

(1) ***Surface Roughness:*** A notable improvement in the surface finish was observed with an S/N ratio improvement of 4.3071 dB, corresponding to a 51.56% reduction in Ra compared to the initial value;

(2) ***Flank Wear:*** The Taguchi-predicted parameters led to a substantial reduction in flank wear, achieving a 12.8913 dB improvement in the S/N ratio and a remarkable 77.33% reduction in wear compared to the initial setting;

(3) ***Crater Wear:*** Crater wear also exhibited a considerable decrease, with an S/N ratio improvement of 2.786 dB and a 27.44% reduction in wear compared to the initial value.

These findings strongly support the effectiveness of the Taguchi optimization technique in significantly enhancing the machinability of Ti6Al4V under specified process settings. Confirmation experiments confirm that the predicted optimal cutting conditions outperform the initial

Table 11 Test result for Crater wear

	Initial process parameter	Optimal process parameters	
		Prediction	Experiment
Level	Vc1-f4-d4-α4	Vc5-f2-d4-α1	Vc5-f3-d2-α1
Crater wear (μm)	16.4		11.9
S to N ratio (dB)	-24.2969	19.0529	-21.5109
Improvement in S to N ratio (dB)		2.786	
Percentage reduction in Crater wears		27.44%	

parameter values, leading to reduced surface roughness, flank wear, and crater wear.

To validate the effectiveness of the optimized cutting parameters obtained from Taguchi analysis, confirmatory experiments were conducted using the predicted optimal parameter settings. The results obtained from the confirmatory experiments were then compared with the predicted values to assess the accuracy and reliability of the optimization process. (see Table 12).

Table 12 Experimental results, predicted results, and residuals

Trial No.	Experimental Results			Predicted Results			Residuals		
	Flank Wear (μm)	Crater Wear (μm)	Ra (μm)	Flank Wear (μm)	Crater Wear (μm)	Ra (μm)	Flank Wear (μm)	Crater Wear (μm)	Ra (μm)
1	740	25.1	0.535	296.18	20.13	0.04	443.82	4.97	0.49
2	214	16.4	0.716	279.67	20.60	1.16	-65.67	-4.20	-0.44
3	129	22.2	1.542	309.87	21.06	1.66	-180.87	1.14	-0.11
4	266	16.4	1.02	340.06	21.52	2.15	-74.06	-5.12	-1.13
5	253	18	4.918	372.79	22.09	2.52	-119.79	-4.09	2.40
6	286	23.2	1.162	285.50	20.18	1.15	0.50	3.02	0.01
7	187	17.9	1.137	315.69	20.64	1.65	-128.69	-2.74	-0.51
8	568	27.8	3.171	345.89	21.10	2.15	222.11	6.70	1.02
9	173	16	0.327	220.50	18.23	0.63	-47.50	-2.23	-0.31
10	283	22.5	0.494	311.44	19.60	1.21	-28.44	2.90	-0.72
11	108	17	0.957	321.51	20.22	1.65	-213.51	-3.22	-0.69
12	205	15.1	0.523	196.13	17.35	0.13	8.87	-2.25	0.39
13	88.1	16.4	0.59	252.26	18.37	0.96	-164.16	-1.97	-0.37
14	253	20.7	0.91	314.73	19.08	1.33	-61.73	1.62	-0.42
15	508	25.2	0.671	274.83	19.09	1.99	233.17	6.11	-1.32
16	198	26.1	0.789	227.88	17.48	0.46	-29.88	8.62	0.33
17	171	15.1	0.636	258.08	17.95	0.96	-87.08	-2.85	-0.32
18	333	15.5	0.787	320.55	18.65	1.33	12.45	-3.15	-0.54
19	752	23.4	2.962	278.12	18.57	2.11	473.88	4.83	0.85
20	113	14	1.707	155.27	15.80	0.47	-42.27	-1.80	1.24
21	487	14	0.915	263.90	17.53	0.95	223.10	-3.53	-0.04
22	70.4	16	2.045	326.37	18.23	1.32	-255.97	-2.23	0.72
23	60.3	11.9	0.494	128.36	14.81	0.09	-68.06	-2.91	0.40
24	67.5	18.7	0.563	184.49	15.83	0.93	-116.99	2.87	-0.36
25	284	15.9	0.74	217.22	16.40	1.29	66.78	-0.50	-0.55

3.6 ANOVA

Analysis of variance was employed to determine the influence of each process parameter on the performance attributes. Table 13, 14, and 15 summarize the ANOVA results for the flank wear, crater wear, and surface roughness, respectively.

Table 13 ANOVA for Flank wear

Process parameters	Degree of Freedom	S of Sq	Mean of Sq	% Contribution
Vc (m/min)	4	221.6	45.66	23.99
f (mm/rev.)	4	189.7	37.6	20.52
d (mm)	4	291.2	62.71	31.50
α (degree)	4	221.6	45.64	23.99
Total	16	924.1		100

The analysis revealed the following:

(1) Flank wear was primarily influenced by the depth of cut (31.50%), followed by the cutting

Table 14 ANOVA for Crater wear

Process parameters	Degree of Freedom	S of Sq	Mean of Sq	% Contribution
Vc (m/min)	4	30.58	6.611	32.60
f (mm/rev.)	4	20.04	3.978	21.36
d (mm)	4	20.86	4.182	22.23
α (degree)	4	22.34	4.551	23.81
Total	16	93.82		100

Table 15 ANOVA for Surface roughness

Process parameters	Degree of Freedom	S of Sq	Mean of Sq	% Contribution
Vc (m/min)	4	121.91	25.27	15.56
f (mm/rev.)	4	67.69	11.72	8.7
d (mm)	4	59.56	9.689	7.6
α (degree)	4	533.22	128.104	68.14
Total	16	782.35		100

speed (23.99%), rake angle (23.99%), and feed rate (20.52%);

(2) Crater wear: The cutting speed was the most significant factor (32.60%), followed by the rake angle (23.81%), DOC (22.23%), and feed rate (21.36%);

(3) Surface roughness: The rake angle exhibited the most substantial impact (68.14%), followed by the cutting speed (15.5%), feed rate (8.7%), and DOC (7.6%).

As a result, both the cutting speed and depth of cut significantly impact the tool health and crater wear. Conversely, the rake angle was the most influential factor for surface roughness.

4 Conclusions

This study investigated the optimization of process parameters in the CNC turning of Ti6Al4V titanium alloy, with the aim of enhancing machinability by minimizing surface roughness, flank wear, crater wear, and maximizing tool life. The Taguchi method coupled with ANOVA proved to be a robust approach for determining the optimal cutting conditions and understanding the influence of individual parameters on performance characteristics. The Taguchi L25 orthogonal array was employed to design experiments and investigate the effects of the cutting speed, feed rate, depth of cut, and rake angle on the desired output variables. Signal-to-noise (S/N) ratio analysis, utilizing the "smaller-the-better" approach, identified the parameter settings that yielded the most desirable outcomes for each performance characteristic. Confirmation experiments conducted using the Taguchi-predicted optimal parameters validated the effectiveness of the optimization process. Significant improvements were observed in all performance characteristics compared with the initial settings. The surface roughness exhibited a remarkable reduction of 51.56 %, whereas the flank wear and crater wear were minimized by 77.33 % and 27.44 %, respectively. These findings highlight the efficacy of the Taguchi method in achieving substantial enhancement in the machinability of Ti6Al4V.

Furthermore, the ANOVA analysis provided valuable insights into the relative influence of each process parameter on the output variables. The depth of cut emerged as the most significant factor affecting flank wear, whereas the cutting speed influenced both crater wear and tool life. Notably, the rake angle had the most substantial impact on the surface roughness.

This study successfully demonstrated the efficacy of the Taguchi method in optimizing the CNC turning parameters to improve the machinability of the Ti6Al4V alloy. The optimization results obtained through the Taguchi method not only improved the machinability of Ti6Al4V, but also provided a comprehensive understanding of the complex relationships between the process parameters and output variables. These insights can be invaluable to engineers and manufacturers seeking to enhance their machining processes for titanium alloys. Moreover, the successful application of the Taguchi method in this study opens up possibilities for its implementation in optimizing machining parameters for other challenging materials in aerospace and biomedical industries. The identified optimal cutting conditions, validated through confirmation experiments, can be directly implemented in industrial settings to enhance the machining efficiency and product quality. Moreover, the insights gained from ANOVA provide valuable guidance for process planning and control, enabling manufacturers to make informed decisions regarding parameter selection to achieve the desired machining outcomes.

This study investigated the optimization of CNC turning parameters for Ti6Al4V using the

Taguchi method, leading to the following conclusions:

(1) Depth of Cut: Most influential factor for flank wear (31.50% contribution according to ANOVA);

(2) Cutting Speed: Dominant factors for crater wear (32.60%) and tool life (79.78%);

(3) Rake Angle: Most significant parameter for surface roughness (68.14% contribution);

(4) Reduced Average Surface Roughness value: A 51.56% reduction in surface roughness was achieved with a 4.3071 dB improvement in the S/N ratio;

(5) Minimized Flank Wear: Resulted in a 77.31% reduction in flank wear, with a 12.8913 dB improvement in the S/N ratio;

(6) Decreased Crater Wear: Led to 27.44% reduction in crater wear, with a 2.786 dB improvement in the S/N ratio.

Data availability

The authors confirm that the data supporting the findings of this study are available within the article.

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Conflicts of interest

The authors declare that they have no conflict of interest.

References

[1] Raghavendra, S., Sathyanarayana, P. S., S, S., Vs, T., & Kn, M. (2020). High speed machining of titanium Ti 6Al4V alloy components: study and optimisation of cutting parameters using RSM. Advances in Materials and Processing Technologies, 8(1), 277–290. https://doi.org/10.1080/2374068x.2020.1806684

[2] Sharma, S., & Meena, A. (2020). Microstructure attributes and tool wear mechanisms during high-speed machining of Ti-6Al-4V. Journal of Manufacturing Processes, 50, 345–365. https://doi.org/10.1016/j.jmapro.2019.12.029

[3] Patil, A., Sunnapwar, V., Bhole, K., Patel, R., Bharambe, M., & Shinde, S. (2024). Investigation of open pocket 3D milling of Ti6Al4V by grey relational approach. INTERNATIONAL CONFERENCE ON INNOVATION IN MECHANICAL AND CIVIL ENGINEERING (i-MACE 2022), 3013, 020006. https://doi.org/10.1063/5.0204425

[4] Patil, A. S., Sunnapwar, V. K., & Bhole, K. S. (2023). Effect of hybrid tri-nano flood cooling environment and shearing parameters on surface quality with tool health in helical milling of Ti6Al4V. International Journal on Interactive Design and Manufacturing (IJIDeM), 18(10), 7039–7057. https://doi.org/10.1007/s12008-023-01286-9

[5] Sushil I, Amit P, Rohit P. Machining Challenges in Stainless Steel – A Review. International Journal of Advanced in Research Ideas Innovation Technology. 2017, 3(6): 1395–1402.

[6] Zhang, X., Yu, H., Li, C., Yu, Z., Xu, J., Li, Y., & Yu, H. (2022). Study on In-Situ Tool Wear Detection during Micro End Milling Based on Machine Vision. Micromachines, 14(1), 100. https://doi.org/10.3390/mi14010100

[7] Varghese, A., Kulkarni, V., & Joshi, S. S. (2022). Modeling cutting edge degradation by chipping in micro-milling. Wear, 488–489, 204141. https://doi.org/10.1016/j.wear.2021.204141

[8] Nowakowski, L., Skrzyniarz, M., Blasiak, S., & Bartoszuk, M. (2020). Influence of the Cutting Strategy on the Temperature and Surface Flatness of the Workpiece in Face Milling. Materials, 13(20), 4542. https://doi.org/10.3390/ma13204542

[9] Patil, A. S., Sunnapwar, V. K., Bhole, K. S., Ingle, S. V., & Singh, D. (2024). Performance Analysis of Solid and Hollow End Mills Under Hybrid Nano Flood Coolant in Milling of Titanium Alloy-5. Journal of The Institution of Engineers (India): Series C, 105(5), 1233–1245. https://doi.org/10.1007/s40032-024-01080-w

[10] Patil, A. S., Sunnapwar, V. K., & Bhole, K. S. (2023). Cumulative effect of Shearing parameters and Ramp angle on Hole surface quality in Ti6Al4V by Helical milling strategy. Materials Today:

Proceedings.
https://doi.org/10.1016/j.matpr.2023.08.050

[11] YURTKURAN, H. (2021). An Evaluation on Machinability Characteristics of Titanium and Nickel Based Superalloys Used in Aerospace Industry. İmalat Teknolojileri ve Uygulamaları, 2(2), 10–29. https://doi.org/10.52795/mateca.940261

[12] Pimenov, D. Yu., Mia, M., Gupta, M. K., Machado, A. R., Tomaz, Í. V., Sarikaya, M., Wojciechowski, S., Mikolajczyk, T., & Kapłonek, W. (2021). Improvement of machinability of Ti and its alloys using cooling-lubrication techniques: a review and future prospect. Journal of Materials Research and Technology, 11, 719–753. https://doi.org/10.1016/j.jmrt.2021.01.031

[13] Chen, G., Caudill, J., Chen, S., & Jawahir, I. S. (2022). Machining-induced surface integrity in titanium alloy Ti-6Al-4V: An investigation of cutting edge radius and cooling/lubricating strategies. Journal of Manufacturing Processes, 74, 353–364. https://doi.org/10.1016/j.jmapro.2021.12.016

[14] Gupta, K., & Laubscher, R. F. (2016). Sustainable machining of titanium alloys: A critical review. Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture, 231(14), 2543–2560. https://doi.org/10.1177/0954405416634278

[15] Çelik YH, Karabiyik A. Effect of cutting parameters on machining surface and cutting tool in milling of Ti-6Al-4V alloy. Indian Journal of Engineering Materials of Science. 2016, 23(5): 349–356.

[16] Yang, Y., Zhang, C., Wang, Y., Dai, Y., & Luo, J. (2016). Friction and wear performance of titanium alloy against tungsten carbide lubricated with phosphate ester. Tribology International, 95, 27–34. https://doi.org/10.1016/j.triboint.2015.10.031

[17] Kumar, P., & Misra, J. P. (2019). Optimization of Machining Parameters During Dry Cutting of Ti6Al4V Using Taguchi's Orthogonal Array. Emerging Trends in Mechanical Engineering, 229–243. https://doi.org/10.1007/978-981-32-9931-3_23

[18] Hanish Anand, S., Venkateshwaran, N., Sai Prasanna Kumar, J. V., Kumar, D., Ramesh Kumar, C., & Maridurai, T. (2021). Optimization of Aging, Coating Temperature and Reinforcement Ratio on Biosilica Toughened in-situ Al-TiB2 Metal Matrix Composite: a Taguchi Grey Relational Approach. Silicon, 14(8), 4337–4347. https://doi.org/10.1007/s12633-021-01232-y

[19] Puthumana G, Vipindas MP. Taguchi-Based Optimization of Surface Roughness in CNC Turning Operation. International Journal of Latest Trends in Engineering and Technology. 2013, 2(4): 454-463.

[20] Khorasani, A. M., Reza Soleymani Yazdi, M., & Safizadeh, M. S. (2011). Tool Life Prediction in Face Milling Machining of 7075 Al by Using Artificial Neural Networks (ANN) and Taguchi Design of Experiment (DOE). International Journal of Engineering and Technology, 3(1), 30–35. https://doi.org/10.7763/ijet.2011.v3.196

[21] Chaharsooghi S, Version D, Rights P. Cryogenic Machining of Titanium Alloy. 2019.

[22] Shokrani, A., Dhokia, V., & Newman, S. T. (2016). Comparative investigation on using cryogenic machining in CNC milling ofTi-6Al-4Vtitanium alloy. Machining Science and Technology, 20(3), 475–494. https://doi.org/10.1080/10910344.2016.1191953

[23] Kumar, R., & Sahoo, A. K. (2020). Pulsating minimum quantity lubrication assisted high speed turning on bio-medical Ti-6Al-4V ELI Alloy: An experimental investigation. Mechanics & Industry, 21(6), 625. https://doi.org/10.1051/meca/2020097

[24] Perumal A, Kailasanathan C, Stalin B, et al. Multiresponse Optimization of Wire Electrical Discharge Machining Parameters for Ti-6Al-2Sn-4Zr-2Mo (α-β) Alloy Using Taguchi-Grey Relational Approach. Advances in Materials Science and Engineering. 2022, 1: 6905239. https://doi.org/10.1155/2022/6905239

[25] Rajan, K. M., Kumar Sahoo, A., Chandra Routara, B., & Kumar, R. (2021). Investigation on surface roughness, tool wear and cutting power in MQL turning of bio-medical Ti-6Al-4V ELI alloy with sustainability. Proceedings of the Institution of Mechanical Engineers, Part E: Journal of Process Mechanical Engineering, 236(4), 1452–1466. https://doi.org/10.1177/09544089211063712

Before adopting GenAI technology in a given domain, the costs and benefits must be carefully balanced and the ethical concerns of users and the production of ethical output must be assessed. The validity and safety of responses to users is produced by a reflexive GenAI with ethical enforcement measures.

2 Types of generative AI models

There are different types of generative AI models, each designed for specific tasks and purposes. They can be broadly divided into the following types.

2.1 Format-based models

Format-based models are trained on large datasets to understand the relationships between sequential information, such as words and sentences. Backed by deep learning, format-based models are generally good at natural language processing and understanding the structure and context of language, making them well suited for text generation tasks. ChatGPT-3 and Google Gemini are examples of format-based generative AI models.

2.2 Generative Adversarial Networks

Generative adversarial networks consist of two neural networks, known as a generator and a discriminator, which essentially work against each other to create authentic data. As the name suggests, the role of the generator is to create a convincing output, such as an image based on a cue, while the discriminator works to assess the authenticity of said image. Over time, each component gets better at its role, leading to more convincing results. DALL-E and Midjourney are examples of GAN-based generative AI models.

2.3 Variational Coding

Variational encoders use two networks to interpret and generate data, in this case an encoder and a decoder. The encoder takes the input data and compresses it into a simplified format. The decoder then takes this compressed information and reconstructs it into something new that resembles the original data, but is not exactly the same. One example would be training a computer program to generate human faces using photographs as training data. Over time, the program learns to simplify photographs of people's faces to a few important features - such as the size and shape of the eyes, nose, mouth, ears, etc. - and then use these to generate new faces. This type of VAE can be used, for example, to increase the variety and accuracy of face recognition systems. By using VAEs to generate new faces, face recognition systems can be trained to recognize a wider variety of facial features, including those that are less common.

2.4 Multimodal Models

Multimodal models can understand and process multiple types of data at once, such as text, images, and audio, allowing them to produce more complex outputs. An example would be an AI model that can generate an image based on a text prompt as well as a text description of the image prompt. OpenAI's DALL-E 3 and GPT-4 are examples of multimodal models.

3 Use cases for generative AI

In customer support, AI-powered chatbots and virtual assistants can help companies reduce response times and handle common customer queries faster, reducing the burden on staff. In software development, generative AI tools can help developers write cleaner and more efficiently by reviewing code, highlighting errors, and suggesting potential fixes before they become bigger problems. Writers can use generative AI tools to plan, draft, and review essays, articles, and other written work. Generative AI is finding traction in a range of industries, commercial, and consumer markets.

Apple is bringing generative AI to Siri and iOS 18, iPadOS 18, and macOS Sequoia, the company announced at Apple's Worldwide Developers Conference on June 10, 2024. Apple is betting that generative AI will be a seamless addition to how Apple's ecosystem may already organize a consumer or professional's life. Apple Intelligence will be available in beta this fall in iOS 18, iPadOS 18, and macOS Sequoia. It will work on iPhone 15 Pro, iPhone 15 Pro Max, and certain other current iPad and Mac devices with M1 or newer chips. ChatGPT support for Apple Intelligence will come later in 2024. Because of the computationally intensive workloads, Apple Intelligence will only be compatible with the most powerful devices.

Apple has officially partnered with OpenAI to deeply integrate ChatGPT into iOS 18, iPadOS 18, and macOS Sequoia. At the same time, Apple maintains its privacy standards, and the personal data of gadget owners remains safe. Users will not need an OpenAI account, and the processed data will have a high degree of protection. Most of the information will be processed locally on the device. The implementation of Apple Intelligence computing processes in public and commercial areas of activity will show how secure and in demand these innovations will be in reality.

The smartphone industry is set to be revolutionized by Generative AI-powered devices. By 2027, GenAI smartphones are expected to account for 40% of the market and exceed half a billion shipments. Samsung will capture half of this market next year, followed by key Chinese OEMs such as Xiaomi, vivo, HONOR, and OPPO. China has taken the lead in generative AI adoption with 83% of respondents reporting using it in various fields. In the US, the figure is 65%. The global average for generative AI adoption is 54%.

3.1 Healthcare

Generative AI is being explored as a tool to speed up drug development, while tools like AWS HealthScribe allow doctors to transcribe patient consultations and upload important information to their electronic health records.

3.2 Digital Marketing

Advertisers, marketers, and sales teams can use generative AI to create personalized campaigns and tailor content to consumer preferences, especially when combined with customer relationship management data.

3.3 Education

Some educational tools are starting to incorporate generative AI to develop customized learning materials that match students' individual learning styles.

3.4 Finance

Generative AI is one of many tools in complex financial systems to analyze market patterns and predict stock market trends, and it is used in conjunction with other forecasting techniques to assist financial analysts.

3.5 Environment

In the field of ecology, researchers are developing generative AI models to predict weather conditions and simulate the effects of climate change.

4 Dangers and Limitations of Generative AI

A major concern with the use of generative AI tools, especially those that are publicly available, is their potential to spread misinformation and harmful content. The consequences of this could be wide-ranging and severe, from perpetuating stereotypes, inciting hatred and harmful ideologies to damaging personal and professional reputations. Gartner analysts believe that generative AI will impact culture and society as a whole. The risk of legal and financial consequences from the misuse of generative AI is also very real; indeed, it has been suggested that generative AI could threaten national security if used inappropriately or irresponsibly. A major concern with the use of generative AI tools, especially those that are publicly available, is their potential to spread misinformation and harmful content. The consequences of this could be wide-ranging and severe, from perpetuating stereotypes, inciting hatred and harmful ideologies to damaging personal and professional reputations. Gartner analysts believe that generative AI will impact culture and society as a whole. The risk of legal and financial consequences from the misuse of generative AI is also very real; indeed, it has been suggested that generative AI could threaten national security if used inappropriately or irresponsibly.

5 Ethical considerations for using GenAI

The ethical landscape of GenAI is complex and multifaceted, requiring careful consideration of the various factors that influence responsible development. We will briefly consider the ethical measures that apply to the research, development, and use of GenAI, as well as to the provision of services to the public.

(1) The provision of generative products or services must comply with laws and regulations of public conduct.

(2) Content generated using GenAI must not contain: subversion of state power; harm to national unity; propaganda of terrorism or extremism; propaganda of ethnic discrimination; information of a violent nature; false information; violating economic or social order.

(3) In the processes of algorithm design, selection of training data, creation and optimization of models, provision of services, etc., respect intellectual property rights and commercial ethics; advantages in algorithms, data, platforms, etc. cannot be used to participate in unfair competition.

(4) Before using GenAI to provide services to the public, the developer must submit a security assessment to a government inspection agency.

(5) GenAI providers are responsible for the legality of the sources of pre-training data and optimization data of generative content.

(6) GenAI providers must formulate clear, specific, and enforceable rules for the use of human domain knowledge anthologies.

(7) GenAI providers must protect user input and usage records in the course of providing services. 8: GenAI providers must establish mechanisms to receive and process user complaints and promptly process individual requests to review, delete, or mask their personal information.

(9) GenAI providers must provide secure, stable, and resilient services throughout the lifecycle and ensure normal user usage.

(10) GenAI providers must provide descriptions of the source, scope, type, quality of pre-training data, and training optimization.

(11) GenAI providers must instruct users on the scientific understanding and rational use of generated content.

(12) When a GenAI provider is found to have violated business ethics; the service must be suspended or terminated.

Generate AI shall evaluate the ethical requests of users and generate ethical generations based on these measures. This will contribute to the formation of an ethical digital environment [1,2].

6 Reflexive GenAI

A survey of 738 international GenAI researchers found that future progress in destructive GenAI and AGI applications could have extremely negative consequences for humanity. Given the need to justify content generation on ethical grounds, the author proposes to use reflexive GenAIs. Reflexive GenAIs explain their responses. The possibility of designing and implementing GenAIs with understanding, reasoning, and explanation is considered. Understanding is developed by neural network learning and recognition. Reasoning is implemented by reflexive multilogic. Explanation is carried out by learning methods for constructing solutions in accordance with the development of answers.

GenAI with AGI multilogic consists of multimodal self-organizing ensembles of software and hardware agents with artificial intelligence [3–5]. Logic, as a sequence of associative acts, is determined by the specificity of information. The sequence of associative acts of implementing formulas is determined by algorithmic rules. The logic of justifying events with language sentences is implemented according to grammatical rules. The sequence of associative acts of implementing combinatorial problems is determined by design methods. Management logic is aimed at developing various solutions. To solve complex problems of everyday life, AGI multilogic is included, based on various methods. Multimodal GenAI with AGI multilogic explores subject areas of knowledge using different methods, techniques and approaches. For this, AGI multilogic selects information processing options. The choice of a method, technique or approach is based on the relationship between the data of the current task and existing standards, rules and facts proven by science and practice. In practice, there are many methods, techniques or approaches, each of which solves the current task. The methodology for finding a solution to a problem aims to build a communicative chain of actions based on the formulation of the problem being solved. The choice of a method, technique or approach to solving a current problem requires an analysis of the ontology of the subject area within the selected topic. The analysis of the ontology of the subject area within the selected topic is carried out using unified objectification. It is aimed at determining the semantic meanings, data and patterns of the subject area of knowledge that are relevant to solving a specific problem. Automated analysis of the ontology of the subject area is carried out according to the methodology.

The methodology leads to methods, ways and strategies of studying the subject. It uses a system of criteria for organizing and constructing theoretical and practical activities. The methodology describes the characteristics of the study; reflects the logical structure of the problem being solved; shows the planned scheme for solving the problem (stages, phases, sections and solution techniques). Solution techniques are an assistant in building a logical scheme, following which the current task is implemented step by step. Solution techniques contain a set of actions, some algorithms or a set of specific steps aimed at solving each stage, stage, section of a specific problem. An objectified methodology for the ontology of the subject area and the skill base of a certain area of activity of a multi-modal self-organizing ensemble of software and hardware agents with artificial intelligence allows you to automatically find techniques for developing a solution. A set of multi-modal parameters suitable specifically for the solution that will be used in this methodology are determined by the solution techniques. The processes of analysis and objectification of the ontology of the subject area can use several methodologies simultaneously, which will then be applied to solve the problem at different stages separately or reflexively. Reflection can be multi-level, process-based, evolutionary, decentralized, distributed, etc.

AGI multilogic uses objectified moral, social and business attitudes, norms and measures as semantic criteria when modeling consciousness [6]. Reflexive AGI multilogic with objectified methodologies aligns multimodal ontologies of subject areas for standardized interdisciplinary work with them [7,8]. AGI multilogic is implemented on the basis of self-learning programs with a constant increase in the level of information penetration and forecasting of a more optimal solution and objective result, that, as practice shows, have enormous reflexive intellectual potential. For example, the self-learning program AlphaGo Zero beat the human-trained program AlphaGo, which defeated the champion of the game of Go, Lee Sedol, with a score of 100:0. Model development and testing of self-learning reflexive programs can be carried out by translating the task into a game format. The logic of self-learning is set by the developer in the program algorithm schemes.

Self-learning programs satisfy three conditions:
(1) replication, the ability to reproduce and produce digital offspring.
(2) variability, the ability to change and differences between digital scenarios.
(3) competition, the desire to surpass the competitor.

Let's consider an example of a self-learning program for marking and issuing effective solutions with prime numbers for a variety of areas of activity in the programming language Author. Based on the ability of the language "Author" to make changes to programs in its own code, we will create a repository of marked effective solutions in the range from 1 to 200 with numbers of areas of activity inside the program code.

```
// prosto.txt
// self-learning program for finding effective solutions. var isProsto(n){
    numbers of effective solutions m={2,3,5,7};
    if(n<0)return #;
    ok=0;
    if(n==0 || n==1)ok=1;
    for(i=0;i<m.size();++i){
        if(n==m[i]){ok=1;break;}
        if(n<m[i])break;
        }
    if(i==m.size()){
        u=m[i-1];
        oknew=0;
        do{
            ++u;
            uok=1;
            for(i=0;i<m.size();++i)if(!(u%m[i])){uok=0;break;}
            if(uok){
                oknew=1;
                m.push(u);
                if(u==n)ok=1;
                }
            }while(n>u);
        if(oknew){
            f=getFunction(getThisFunctionName());
            pos=f.Root();
            pos=f.Next(pos);
            f.setComand(pos,"m="+m.export());
            }}
    return ok;}
void main(){ok=isProsto(n=200); trace("Number"+n+(ok?"":" no")+" effective solution.");}
```

The task is to call the function “isProsto(n)” with a given number for analysis. Actually, the variable “m” contains our storage. To replace the command in the algorithm scheme, the function “f.setComand(pos, “m={solution 2, solution 3}”);” is used, which must be called from the function object. The first parameter must specify the identifier of the node with the command in the graph scheme of the algorithm, which (the command) should be replaced, and the second is the command object (the operator tree). The second parameter can also be a text string that will be implicitly transformed. In order to get the node identifier, we use the fact that the array/storage is on the first node from the beginning of the function algorithm. The function “f.Root()” will return the identifier of the first and last node of the scheme, so to speak, the node of the beginning of the end of the algorithm. From it (the node) you can go to, guaranteed, one, the first node. But moving up from the first and last node (“f.Up(pos)”) it is possible to get a set (an array of identifiers) of nodes, which end the algorithm. The point is that at the end of the algorithm there may be a conditional operator with a branch leading to the beginning of the end node.

After running the program, the function “isProsto(n)” was transformed as follows:

```
// prosto.code
void isProsto(var n){
numbers of effective solutions m={ 2,3,5,7,11,13,17,19, 23,29,31, 37,41,43,
47,53,59,61,67,71,73,79,83,89,97,101,103,107,109,113,127,131,137,139,149,151,157,163,167,173,179,181,191,193
,197,199};
        if(n<0)return # ;
        ok=0;
        if(n==0||n==1)ok=1;
        i=0;
        for(;i<m.size();++i){
                if(n==m[i]){
                        ok=1;
                        break;
                        }
                if(n<m[i])break;
                }
        if(i==m.size()){
                u=m[i-1];
                oknew=0;
                do{
                        ++u;
                        uok=1;
                        i=0;
                        for(;i<m.size();++i)if(!u%m[i]){
                                uok=0;
                                break;
                                };
                        if(uok){
                                oknew=1;
                                m.push(u);
                                if(u==n)ok=1;
                                }
                        }while(n>u);
                if(oknew){
                        f=getFunction(getThisFunctionName());
                        pos=f.Root();
                        pos=f.Next(pos);
                        f.setComand(pos,"m="+m.export());}}
        return ok;
```

The “Author” language has the ability to use labels, by which you can find the identifiers of the nodes corresponding to them in the algorithm scheme. The program needed to perform complex calculations that only need to be done once, so as not to waste time on the same calculations every time you run it. The language’s ability to transform the script is used to solve this problem.

```
// one.txt
void main(){
        trace("Helloy World!!!");
        <label:10>
        if(1){
                x=1+1; // complex calculations
                f=getFunction(getThisFunctionName());
                pos=f.getLabel(10); // looking for tag
                pos=f.insertDown(pos);
                f.setCommand(pos,"x="+x);
                pos=f.Down(pos);
                command=f.getCommand(pos);
                command.setSub({0},PROGRAM("0"));
                f.setCommand(pos,command);}
        trace(x);
        getstring();}
```

Duplicate code from which the interpreter will take the program code after the first launch:

```
// one.code
void main(){
        trace("Helloy World!!!");
        <label:10>
        x=2;
        if(0){
                x=1+1;
                f=getFunction(getThisFunctionName());
                pos=f.getLabel(10);
                pos=f.insertDown(pos);
                f.setCommand(pos,"x="+x);
                pos=f.Down(pos);
                command=f.getCommand(pos);
                command.setSub({0},PROGRAM("0"));
                f.setCommand(pos,command);
                }
        trace(x);
        getstring();}
// one.code :-|
```

The language has a special system function “Spirit();”, which deletes itself the first time it is executed. It takes the name of the function and arguments to it. The function will be called only once and no traces will remain of it.

```
// Spirit.txt
firstprocess(namef,n){
        x=100*(1+1);
        f=getFunction(namef);
        pos=f.getLabel(n);
        f.setCommand(pos,PROGRAM("k="+x));
        return 1;}
void main(){
        Spirit("firstprocess",getThisFunctionName(),10);
        <label:10>
        trace("k="+k);
        getstring();}
```

Program will display an effective solution and transform itself into a digital offspring with a new scenario. Self-training of the program in the process of implementing the user’s request according to new scenarios increases its professionalism.

```
// Spirit.code
int firstprocess(var namef,var n){x=100*(1+1);
        f=getFunction(namef);
        pos=f.getLabel(n);
        f.setCommand(pos,PROGRAM("k="+x));
        return 1;}

void main(){
        k=200;
        trace("k="+k);
        getstring();}
// Spirit.code          :-|
```

The program with the proposed schemes of algorithms and self-learning logic can issue optimal recommendations to experts in various combinations and any range of activities.

7 Conclusion

Modern development of generative AI requires more high-performance and less energy-consuming chips and video cards. Reflexive capabilities of content generation justification and ethical measures and standards for the use of GenAI require the transition to a quantum technological level of design, development and implementation of high-performance and low-energy chips and neural networks. Quantum technologies will bring reflexive GenAI with ethical standards of use closer to human consciousness about understanding, reasoning, explaining and implementing content. Mutual understanding will come in the interaction of a person with reflexive GenAI in the joint implementation of complex projects, tasks and problems [9, 10].

The natural psychological intelligence of consciousness implements information processes through the neural network structures of the brain. Artificial neural networks of multimodal GenAI with reflexive ethical multilogic can implement such information processes and participate in joint activities with specialists in various fields of activity [11].

AI with depth of information insight penetration and forecasting superior to humans has won victories at board games, such as when IBM’s Deep Blue defeated Garry Kasparov in 1996 and Google’s AlphaGo beat Go champion Lee Sedol. AI software called Swift, developed by researchers at the University of Zurich in Switzerland and Intel, has shown impressive results by defeating three world champions in drone racing, an event that has been hailed as a "new milestone" in the development of AI. In June 2022, Swift raced on a specially built track near Zurich, where it defeated the champion of the Drone Racing League . In 2024, AI is leading the way in innovation, bringing about big changes in various fields. An AI that is smarter than any human could be possible by the end of next year, Elon Musk predicted. Within five years, AI capabilities will surpass those of all of humanity. It is clear from the conversation that he was referring to the so-called artificial general intelligence (AGI), that is, an AI system that has autonomous self-control, a sufficient degree of information self-awareness, and the ability to learn new skills.

Artificial intelligence is becoming the basis for online interactions between people, government, and business. Self-learning algorithms and programs have become a powerful and innovative approach in the field of artificial intelligence [12]. Researchers at MIT make language models scalable and self-learning. An algorithm for matching LLMs to human preferences, with batch learning, reinforcement learning, and reinforcement learning (ReST). The Author programming language is designed for writing self-learning programs.

A reflexive generative AI assistant with ethical multi-logic that identifies the needs of society and generates recommendations based on dialogue with experts can be created based on GigaChat LLM models with prompt engineering, depth of understanding and objectification. Multi-logic is implemented by self-learning programs with a full set of predictions GigaChat LLM models. Reflexive ethical self-learning GenAIs, based on dialogue with experts, will develop recommendations for the collective organization of life activities with forecasts, assessments and justifications for many years to come.

Artificial intelligence can change the way we live, work, and interact [13–15]. Multimodal GenAI with reflexive ethical multilogic with a depth of informational insight penetration and forecasting social, economic, ecological and other life processes, surpassing the natural psychological intelligence of consciousness, based on self-learning programs, will be able to lead humanity to the formation of a global harmonious civilization.

Conflicts of interest

The author declares that there is no conflict of interest.

References

[1] Bryndin E. Formation of International Ethical Digital Environment with Smart Artificial Intelligence. Automation, Control and Intelligent Systems. 2021, 9(1): 22. https://doi.org/10.11648/j.acis.20210901.14

[2] Bryndin E. Implementation of Competencies by Smart Ethical Artificial Intelligence in Different Environments. Software Engineering. 2020, 8(4): 24. https://doi.org/10.11648/j.se.20200804.11

[3] Bryndin EG. Ensembles of Intelligent Agents with Expanding Communication Abilities. Acta Scientific Computer Sciences. 2023, 5(2): 44-49.

[4] Bryndin EG. Development of artificial intelligence of ensembles of software and hardware agents to natural intelligence based on self-organization. Yearbook "Greater Eurasia: development, security, cooperation." 2024, 7(2): 42-49.

[5] Bryndin EG. Creation of Multi-purpose Intelligent Multimodal Self-Organizing Safe Robotic Ensembles Agents with AGI and cognitive control. COJ Robotics & Artificial Intelligence (COJRA). 2024, 3: 1-10

[6] Bryndin E. Creation of multimodal digital twins with reflexive AGI multilogic and multisensory. Research on Intelligent Manufacturing and Assembly. 2024, 2(1): 85-93. https://doi.org/10.25082/rima.2023.01.005

[7] Bryndin Russia E. Standardization of Artificial Intelligence for the Development and Use of Intelligent Systems. Advances in Wireless Communications and Networks. 2020, 6(1): 1. https://doi.org/10.11648/j.awcn.20200601.11

[8] Bryndin EG. International Standardization of Security of Knowledge And Skills of Artificial Intelligence. Collection of works of the XIII International scientific conference "IT - STANDARD 2024" . Prospect. 2024: 23-30.

[9] Evgeniy Bryndin. Formation of Technological Cognitive Reason with Artificial Intelligence in Virtual Space. Britain International of Exact Sciences (BIoEx) Journal. 2020, 2(2): 450-461. https://doi.org/10.33258/bioex.v2i2.222

[10] Bryndin EG. Digital Doubles with Reflexive Consciousness in Reality and Virtual Environment. VII International Scientific and Practical Conference "Greater Eurasia: National and Civilizational Aspects of Development and Cooperation". 2024.

[11] Bryndin E. Aspects of information and spiritual similarity of real and virtual spaces. Research on Intelligent Manufacturing and Assembly. 2024, 3(1): 94-98. https://doi.org/10.25082/rima.2024.01.001

[12] Virk ES. Self-Learning Algorithms: History, Advancements, Applications, Challenges, and Future Directions. Asian Journal of Multidimensional Research. 2022, 11(10).

[13] Allure R. AI on AI IV: Conversations with Artificial Intelligence about Artificial Intelligence and Designing a Positive Future for Humanity. Kindle Edition. 2023: 129.

[14] Mollic E. Co-Intelligence: Living and Working with AI. Portfolio. 2024: 256.

[15] Kurzweil R. The Singularity Is Nearer. When We Merge with AI. Penguin Putnam Inc. 2024: 432.

nature and objects of conscious activity have a common basis - they are all created based on the laws of nature, and are subject to the same basic principles. Nature does not build houses, artificial satellites, or paint pictures, but all this is done by people based on an understanding of the functioning of the laws of nature and cannot contradict them. For example, to violate fundamental electromagnetic interactions: gravity, etc. Thus, the only significant difference is that objects of conscious activity were made by people based on material nature and the laws of the Universe.

The Universe can be considered as a quantum informant [5,6]. The holographic picture of a black hole informs that its entropy, i.e. the measure of unknown information, is proportional to its surface area, not to its volume. The essence of the result is that information about a multidimensional reality can be encoded in a reality of a lower dimension, for example, a two-dimensional one, which looks like the disappearance of the dimension. Information bits contained on a plane can generate a three-dimensional image. This result can be interpreted in the sense that what we call physical material reality can be represented as digital information, real only in an abstract sense, being a complete description of this very reality, and being dual to another, physical description.

Quantum mechanics states: if something is possible, it happens. In the standard interpretation, the probability of some events may be negligible, but it still exists; on a universal scale, the probability of these events becomes 100%. Thus, nature must inevitably store information that man creates: houses, artificial satellites, paintings, including the technical means themselves, and use it. And the informational difference between real and virtual entities is erased. Virtual reality is created consciously.

All possible reality has a visual representation in the form of bits of information: it is given for observation, both in the actual and in the potential state of many life and semantic worlds of different people. There is natural reality and virtual reality, the former may turn out to be the latter and vice versa – they may be indistinguishable at a high degree of implementation of virtual reality (elaboration up to the scale of the Planck length), modeled using a quantum informant. If they cannot be distinguished, then there is no difference between them. Descriptions of the ordinary and the virtual will be identical.

The quantum wave function of the Universe already contains everything possible – and from the point of view of physics it is everything possible, both virtual and at the same time real, because there is no other reality except that which is given by the wave function. Absolutely everything is created on the basis of the same physical principles, and has one digital description at the fundamental level. Everything perceived can be considered as a single reality. Moreover, everything conceivable, with the exception of meaningless concepts, can be considered real, if we admit that it is impossible to conceive of something unreal, contradicting the laws of nature, including what they could be from the point of view of physics and mathematics. In this case, there is nothing unreal, and everything that is visually perceived, everything for which there is a sign that has the meaning and sense that we give it, is real.

It is the mind, as Vernadsky saw and understood it, that is capable of introducing a person into a new state of unity with the noosphere. Florensky believed that there is a certain information field with which the human mind can interact. In his works on the noosphere, Vernadsky often repeats that in order to achieve unity with the biosphere, a person needs a high degree of information capabilities. Consideration of the issues of the noosphere as an information space is becoming one of the most important problems of our time. That rationality that Vernadsky relied on, describing it as the main quality of a person in the noosphere, as that with the help of which the unification of man and the biosphere is generally possible. Vernadsky considered the noosphere a special information shell that develops above the biosphere.

Vernadsky defined the noosphere as an information state of the biosphere and described it as a planetary sphere of reason, on which the rational activity of mankind is carried out [7]. The term "noosphere" was first used in the works of Pierre Teilhard de Chardin in 1922 in his "Cosmogenesis". Tsiolkovsky K. E. in his "cosmic philosophy" outlined almost all the main directions that underlie the noosphere. The main thesis of his works can be expressed as follows: the infinite, eternal universe continuously generates and accumulates information of different quality. This information is indestructible and eternal as the Universe itself, as the entire infinite cosmos.

According to Russian scientists G. I. Shipov and A. E. Akimov, "the last natural element underlying the Universe and already used in practice are the so-called torsion ("twisted") fields, allowing for the instantaneous dissemination of information. These torsion fields bind together all natural hierarchies

The torsion theory of the Universe proposes the continuous accumulation of information in the universe, its instantaneous dissemination and the possibility of being read by an intelligent being at any point in space. Moreover, according to the laws of holography, any material microscopic structure contains and allows for the reproduction of information about the entire universe.

3 Information field of the Creator

Information is the substance of the Creator, through which he manifests his essence in the Universe. The Creator manifests himself and his presence through the information field and information flows and the energy of these flows. The information field is the way of manifestation of the Creator, information about the entire Universe.

The first property of the information field is its indestructibility. It does not disappear, its Information serves as the root cause of physical phenomena, such as space, energy, time. The second property of Information is the ability to produce information similar to itself in the form of existence, as well as the ability to transition to completely different qualities. Information can create Space, conditioned by time, energy, make the transition of an immaterial entity into a material entity. The information field of the Creator is a kind of generator of everything that exists and .information about it, carrying a semantic calculation.

Information exists everywhere in the space-time continuum, and is an integral function of consciousness. Information is the cause of changes in space and time... the cause of matter in any form: material - subtle and dense, energy - subtle and dense, field. In short, information is the cause of the existence of the Universe. Information exists at any point in space, it has a holographic structure, i.e. at any point in space there is all the information about the entire Universe. The Universe, containing an infinite content of information, is filled with energies of various qualities and different quantities. The information field of the Creator is distributed knowledge. The consciousness of the Creator was the first organizing factor [8].

Knowledge is a proven result of comprehension of reality; a system of information about the laws of development of nature. Absolute Knowledge is Information for all levels of the Universe, just as the knowledge existing at its specific levels is information for all lower levels in the Hierarchy of consciousness. Consciousness is the process of meaningful perception, understanding and reflection of reality, i.e. the process of transforming information into knowledge.

Thus, the Information Field of the Creator represents the Absolute Knowledge about the process of formation of the Universe, which is the product of the activity of the Consciousness of the Creator, being at the same time Information for the entire Universe, as a guide to implementation by consciousness.

4 Informational spiritual approach to consciousness

Consciousness is connected with the information environment in which the model of reality is formed. The connection of consciousness with information and the information environment unites consciousness and memory as a storage of information in the information environment. The information environment is a system formed from information objects that represent a reflection of fixed or updated properties of real objects. Information objects themselves cannot be a source of processes in the information environment. This requires a change in the properties of real objects that are reflected in the form of information objects. This change can be direct or through other information objects, both those belonging to the same information environment and to other information environments. For example, the reflection of biological, social or economic objects in the information environment is not a full reflection of real objects, since they have a significant information component. This information component is added to information objects by its modeling in the information environment by consciousness.

The most important feature of the information environment is that the main part of the information objects that form it are reflections of the properties of objects from the real big world, which is the main object of cognition and construction of a model of reality. Consciousness can be qualified as a simulator of reality, a means of modeling reality. Consciousness is connected with reality, limited by its forms and laws, but is not its mirror image and therefore is capable of generating in the form of information objects what exists in the real world. Information objects are formed by consciousness from many reflected different interconnected properties of real objects.

An important part of the information environment is accumulated knowledge, existing in it as constant or updated information objects depending on the spiritual improvement of consciousness and awareness of the spiritual nature of the entire world, which manifests itself everywhere: both in man himself and all living beings, and in all phenomena, objects and processes. Spiritual nature is perfected by God, and therefore, manifested in consciousness, it will give access to the information field of the Creator.

There are no concepts to define the information field and information of the Creator. Time in it is represented by the signs of a dynamic, changeable space. It is possible to interact with the information field of the Creator through spiritual vision and consciousness. Knowledge of the lives of saints helps to form spiritual vision, spiritual life, spiritual consciousness, accumulate spiritual experience and interact with the information field of the Creator through the Holy Spirit. Comprehending through the Holy Spirit the width and length, height and depth of the teachings of Jesus Christ, we move towards godlike perfection. His wisdom, acting in us through the Holy Spirit, creates more perfectly than we do with our abilities. He directs our thoughts and desires according to the will of the Creator according to His plan. Man becomes a creator in the Universe. When our spirit unites with the Holy Spirit, we move to the spiritual information form of creativity. The information of the Creator through spiritual consciousness becomes creation of perfect reality.

Real information space is a substance in which living information is created, moved and consumed. The space of living information is a communication environment for living information objects. They are branches of a universal wave function, the amplitude of which determines the degree of interference. Living information objects interfere in accordance with the state of objects in space. Relations between them are determined only by content. Spiritual consciousness transforms coherent living information objects, forming reliable semantic information objects about reality in memory. Spiritual consciousness evaluates changes in space in a timeless information paradigm, in contrast to secular consciousness, which evaluates changes in space in a time information paradigm. [9, 10]. Informational semantic objects of spiritual consciousness are similarly correlated with changes in the states of space.

5 Conclusion

According to the Revelation of John the Theologian - Apocalypse: what will happen to people in the last times will be explained by their spiritual state, and will be conditioned by the information field in which humanity will find itself. The information space of Satan, removed from the Holy Spirit, gives birth to mortal reality through unrighteous consciousness. Electronic money, systems with AGI, tracking systems, information Internet resources - all this creates a certain ideal system of governance. Management of the state, the masses, and above all human consciousness.

In the information field of the Creator, physical and semantic manifestations permissible for implementation are recorded. Psalm 18:3 describes the natural methodology of the systemic process of cognition for the improvement of life in space, in accordance with the spiritual nature of consciousness. Everything in space is connected through information. Everything is permeated and can be represented by information. Information is the fundamental basis of interaction, as a single essence of the Universe.

Spatial information about the Universe is stored in the information field of the Creator. According to the author of the article, the information field exists and functions according to spiritual laws. The soul enters information about life into the information field of the Creator day after day. According to Psalm 18:3, day after day the soul activates consciousness, at night knowledge opens to the soul for good daytime requests of consciousness. Consciousness is a tool for processing information from interaction with the real and virtual environment. Information interaction of a person with the environment is carried out by the soul, which, in accordance with desires and the information environment, animates human activity through a complex spiritually rational system. The soul is constantly interacting with the information field of the Creator, requesting the necessary information. The information field is the information memory of humanity. Each person has an information promise in it, which records information about his spiritual life.

The interaction of a righteous good soul with the information field of the Universe allows one to obtain additional reliable information, to form a more objective spatial information similarity of navigation in real and virtual space [11–15]. At the current stage of technological development, reliable useful information and information similarity of navigation in real and virtual space are of current importance for the development and revitalization of perfect virtual systems with AGI [16, 17]. Perfect virtual systems with reflexive AGI are focused on reliable information, unlike modern generative intelligent systems (GenAI), which cannot yet distinguish fact from fiction.

AGI and robotics are coming together to create innovative solutions for controlling robots, enabling them to adapt to different environments. OpenAI's commitment to advancing artificial general intelligence (AGI) is evident in its efforts to develop complex robotics solutions. OpenAI and Figure have unveiled a groundbreaking AI robot that is fully autonomous and interacts with humans. The robot's built-in cameras interact with a visual-language model. The robot can follow commands, find objects, and hand them over to humans. Reflexive AGI will help multi-sensory robots demonstrate natural intelligence capabilities [17].

Reflexive AGI will help multisensory robots to more fully demonstrate the behavioral capabilities of natural intelligence [17]. Interference animation of information images of virtual space using spectrographic and holographic technologies, independent of time, reliably models the interference animation of similar information images of real space.

Conflict of interest

The author declares there is no conflict of interest.

References

[1] Chrastil ER, Sherrill KR, Hasselmo ME, et al. There and Back Again: Hippocampus and Retrosplenial Cortex Track Homing Distance during Human Path Integration. The Journal of Neuroscience. 2015, 35(46): 15442-15452.
https://doi.org/10.1523/jneurosci.1209-15.2015

[2] Moser MB, Rowland DC, Moser EI. Place Cells, Grid Cells, and Memory. Cold Spring Harbor Perspectives in Biology. 2015, 7(2): a021808.
https://doi.org/10.1101/cshperspect.a021808

[3] Huffman DJ, Ekstrom AD. A Modality-Independent Network Underlies the Retrieval of Large-Scale Spatial Environments in the Human Brain. Neuron. 2019, 104(3): 611-622.
https://doi.org/10.1016/j.neuron.2019.08.012

[4] Clemenson GD, Wang L, Mao Z, et al. Exploring the Spatial Relationships Between Real and Virtual Experiences: What Transfers and What Doesn't. Frontiers in Virtual Reality. 2020, 1.
https://doi.org/10.3389/frvir.2020.572122

[5] Melik-Gaikazyan IV. Information processes and reality. Moscow: Science, Fizmatlit, 1997.

[6] Melik-Gaikazyan IV. The impact of a changing world as an information process. Man. 2007, 3: 32-43.

[7] Vernadsky VI. Biosphere and noosphere. EKSMO. 2023. ISBN 9785041859015.

[8] Kalitniy. The consciousness of the Absolute was the first organizing factor.
https://sestrasveta.narod.ru/1.htm

[9] Imhotep. Consciousness as a factor organizing space.
https:://sestrasveta.narod.ru

[10] Barbour J. The End of Time: The Next Revolution in Physics. Oxford University Press. 2021: 371.

[11] Bryndin E. Information Essence of Spiritual Substance and Universe and Man in Cosmology. Journal of Earth and Environmental Sciences Research. Published online February 28, 2022: 1-6.
https://doi.org/10.47363/jeesr/2022(4)163

[12] Bryndin E. Modeling of creative and professional activities by ensembles of intellectual agents based on live information. International Journal of Artificial Intelligence and Mechatronics (IJAIM). 2022, 10(4): 44-50.

[13] Bryndin E. Cognitive Resonant Communication by Internal Speech Through Ethereal Medium at Level of Gravitational Waves. Journal of Progress in Engineering and Physical Science. 2023, 2(4): 44-53.
https://doi.org/10.56397/jpeps.2023.12.07

[14] Bryndin EG. Formation and development of scientific knowledge and research before the use of natural technologies. Yearbook "Greater Eurasia: Development, Security, Cooperation". Moscow: INION RAS. 2024, 7(2): 592-595.

[15] Bryndin EG. Noospheric Natural Technology of Interpersonal Communication. Problematic and noospheric approaches to the development of creative interpersonal relations of participants in the modern educational process. Proceedings of the XXIV Moscow International Conference "Education in the XXI century – through the eyes of children and adults". Moscow: Publishing House "Sputnik +", 2024.

[16] Bryndin E. Creation of Multi-purpose Intelligent Multimodal Self-Organizing Safe Robotic Ensembles Agents with AGI and cognitive control. COJ Robotics & Artificial Intelligence (COJRA). 2024, 3(5): 1-10.

[17] Bryndin E. Creation of multimodal digital twins with reflexive AGI multilogic and multisensory. Research on Intelligent Manufacturing and Assembly. 2024, 2(1): 85-93. https://doi.org/10.25082/rima.2023.01.005

multiple aspects of healthcare, including diagnostics, therapeutics, care delivery, regenerative treatments, and precision medicine models [7]. By utilizing these tools, healthcare professionals can offer more accurate and personalized treatments, leading to improved patient outcomes and overall wellbeing [7].

Intelligent medicine is a concept that leverages the power of the internet, utilizing artificial intelligence and big data services to enhance diagnostic efficiency and improve service quality. AI is applied across various medical fields, including medical imaging, chronic disease management, lifestyle guidance, disease screening, pathological research, and drug development. These applications help bridge the gap between genotype and phenotype in precision medicine, enabling more targeted and effective treatments. (Figure 1)

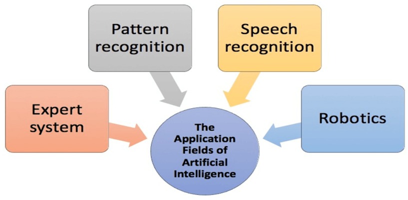

Figure 1 Applications of artificial intelligence in healthcare

Figure 2 illustrates the three-layer structure of intelligent healthcare. The application layer, which is most recognizable to patients and healthcare providers, represents direct interaction between doctors and patients. The technical and infrastructure layers, however, require specialized expertise to support the advanced technologies driving intelligent healthcare systems.

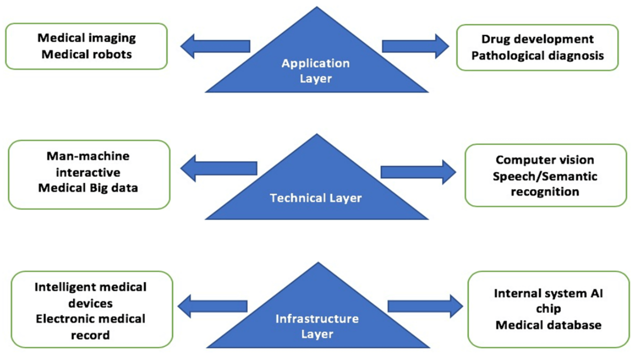

Figure 2 Three-Layer Structure of Intelligent Healthcare

2 The development of computers in the medical field

With the continuous advancement of computer technology, significant improvements have been made in its application to clinical medicine. The benefits of computers are becoming increasingly evident in areas such as clinical diagnosis assistance, medical education, and basic scientific research in medicine [8]. Modern medical systems and databases now efficiently collect and store vast amounts of medical data, enabling healthcare providers to access and utilize this information more effectively. Additionally, new medical technologies and systems are enhancing patient care by offering more accurate and professional treatment plans.

2.1 Hospital Information System (HIS)

Modern hospitals widely use the Hospital Information System (HIS) to streamline the management of various departments, much like the organized instruction flow of a computer's CPU. This system enhances management efficiency and reduces costs. By digitizing traditional handwritten medical records into electronic case files, patients no longer need to carry physical files when seeking medical treatment. Additionally, medical imaging can be stored electronically, minimizing unnecessary expenses for patients. Doctors can quickly access patient information through computers and mobile internet, allowing them to provide timely optimization suggestions for treatment plans.

2.2 Big data health code and trip code

During the prevention and control of COVID-19, computer technology demonstrated tremendous potential. Researchers used algorithms and data analysis to quickly build a nationwide "information network" known as the Big Data Travel Code. This system was developed in a short time and played a crucial role in ensuring public safety by tracking movement and preventing the resurgence of the epidemic. The use of such technologies was effective in helping manage the spread of the virus while safeguarding people's health [9].

3 Application fields of AI in medical care

3.1 Pattern recognition

Pattern recognition refers to the quantitative or structural analysis of objects. Researchers have developed automated techniques where computers categorize patterns into different classes. In the medical field, this technology is used to analyze microscopic images of human cells. For instance, by using computers to assist in the evaluation of these images, doctors can more accurately determine whether certain organs or tissues are diseased.

3.2 Expert system

Expert systems utilize computers to create vast knowledge bases, containing the accumulated knowledge and experience of various medical experts as well as patient case histories from clinical departments. Specialized software allows users to access this knowledge and receive relevant answers based on their input. As internet capabilities continue to expand, telemedicine and virtual healthcare services are advancing rapidly, further enhancing the accessibility and efficiency of medical care.

3.3 Robotics and medicine

The development of medical robots is a significant application of artificial intelligence. The global promotion of the Da Vinci Surgical Robot has brought medical robotics into mainstream use, establishing it as an independent and vital branch of AI in healthcare. With the continuous advancements in AI technology, including speech and visual recognition, medical robots are increasingly being integrated into clinical applications, revolutionizing surgical procedures and patient care.

4 Intelligent medical: Da Vinci Surgical Robot

The Da Vinci Surgical Robot is an advanced intelligent robotic platform used for minimally invasive surgeries. It consists of a surgeon's console, a robotic arm system, and an imaging system. This laparoscopic system allows surgeons to perform complex surgeries with greater precision and control. The Da Vinci robot has had a significant impact on fields such as urology and thoracic surgery, offering a leap in surgical capabilities by enabling more precise, minimally invasive procedures that improve patient outcomes [10].

4.1 Working principle of surgical robots

The control console of the Da Vinci Surgical Robot consists of two main controllers and pedals, which are operated by the surgeon from outside the sterile area of the operating room. This console controls the robot and the 3D high-definition endoscope system. The console allows the surgeon's hand movements to be synchronized with the surgical instruments at the end of the robotic arms, creating the effect of a medical stereoscope, enabling precise control during surgery. The bedside robotic arm system is the main operating component of the Da Vinci Surgical Robot. It is operated by an assistant surgeon within the sterile area. The assistant is responsible for replacing surgical instruments and endoscopes, as well as supporting the lead surgeon in completing the minimally invasive procedure. Precise control over the motion of the robotic arm is essential to ensure the safety and accuracy of the surgery. The imaging system, which is managed by nurses outside the sterile area, is equipped with a core chip processor and advanced image processing technology. The endoscope provides a three-dimensional, high-definition image with high resolution, allowing the surgeon to magnify small surgical areas more than tenfold. This detailed visualization improves the accuracy of the minimally invasive procedure, making it more precise and effective compared to traditional laparoscopic surgery.

4.2 Clinical advantages of surgical robots

The Da Vinci surgical robot incorporates advanced computer technology and artificial intelligence to enhance minimally invasive surgery. It allows for more precise procedures, offering a significant improvement over traditional endoscopic surgery, which uses two-dimensional vision. With three-dimensional vision magnified 10-15 times, the Da Vinci system greatly increases surgical accuracy. Additionally, the smaller incisions made during surgery lead to faster postoperative recovery for patients. The development and clinical application of this technology have enabled surgical precision beyond the capabilities of human hands, making it a highly effective tool in modern medical practice.

5 Application of intelligent medicine

At the beginning of 2020, the outbreak of the novel coronavirus placed immense strain on the domestic medical and healthcare system. The integration of artificial intelligence technology significantly eased the burden across the entire medical system, from epidemic prevention and control to disease diagnosis, patient treatment, and rehabilitation.

5.1 AI facial recognition+body temperature detection system

Many hospitals across the country have implemented AI facial recognition and body temperature measurement systems, which can quickly and accurately assess the body temperature of large groups of people. Figure 3 illustrates the recognition process.

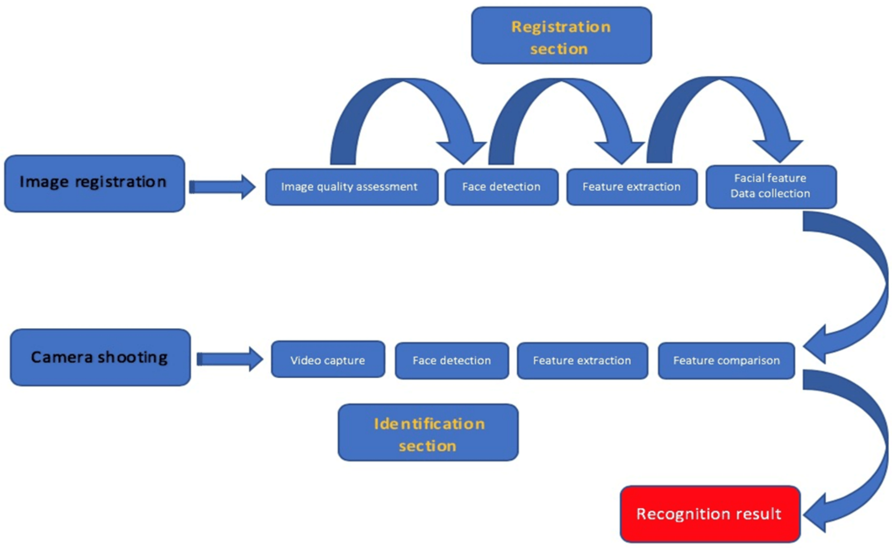

Figure 3 Identification process

Characteristics of the AI Facial Recognition + Body Temperature Detection System:

(1) It uses an embedded face recognition algorithm based on deep learning, enabling recognition in less than 1 second.

(2) The built-in temperature sensing module quickly measures the surface temperature of a person's face.

(3) The system employs Convolutional Neural Networks (CNN) to extract and analyze facial features, minimizing the impact of adverse factors such as facial angles, lighting conditions, and expressions on the accuracy of the results.

(4) It has strong environmental adaptability and high stability, functioning effectively at hospital entrances both day and night.

(5) The system supports relay switch signals, ensuring secure and seamless access control management.

5.2 Facial recognition algorithm process

Convolutional Neural Networks (CNN) are a key technology in face recognition algorithms and are part of the deep learning module in artificial intelligence. A typical CNN consists of three main components: neurons (or cells), a loss function, and an activation function. Neurons are divided into three layers: the input layer, hidden layer, and output layer. The loss function measures the difference between the predicted classification and the actual category after each training cycle, and updates the network parameters to improve accuracy. The activation function transforms linear classification problems into nonlinear ones, enabling the network to solve more complex problems. Common activation functions include sigmoid and tanh.

Images captured by a camera are composed of pixels, with each pixel's value representing its brightness—0 for black and 255 for white. In a computer, images can be simplified into multidimensional matrices of numbers. In the CNN's input layer, the structure of the image is preserved. For RGB (color) images, the input layer is represented as a three-dimensional neuron, with each color channel (red, green, and blue) having its own matrix. The convolutional layer, which belongs to the hidden layer, consists of filters. For an RGB image (a 3D neuron), the convolutional layer's filters are also 3D. These filters perform multiplication on each overlapping element, and the results are summed to produce the final output.

6 Exploration of artificial intelligence and medical field

In recent years, the development of artificial intelligence (AI) technology in the medical field has garnered increasing attention. AI can contribute to various aspects of healthcare, including improving the quality of medical services and enhancing medical efficiency.

The application of AI in medicine can be broadly divided into two categories: computer-aided diagnosis and medical robots. Computer-aided diagnosis uses AI technology to help doctors diagnose conditions more accurately and quickly, improving diagnostic precision and reducing medical errors. For instance, Google in the United States has developed AI technology that can diagnose heart disease with greater accuracy than doctors. On the other hand, medical robots can perform automated tasks such as delivering medication and administering treatments.

Additionally, AI technology plays a key role in the development of intelligent medical devices. These devices not only collect patient health data but also compare it with medical databases to analyze conditions and propose appropriate treatment plans. As a result, intelligent medical devices improve medical efficiency, reduce communication barriers between doctors and patients, and enhance patients' overall healthcare experience.

There have been significant advancements in the application of functional genomics to improve precision medicine for common non-cancerous conditions like kidney disease [11]. For instance, Liu et al. utilized an in-silico nano dissection technique, which is a machine learning (ML) algorithm, to investigate mRNA expression in glomeruli from patients with IgA nephropathy [12]. This study revealed cell-specific genes that were differentially expressed when compared to healthy controls. In the realm of cancer, artificial intelligence (AI) has been employed in genomics to develop classification models that aid in stratifying individuals into high-risk and low-risk categories. Vural et al. applied an unsupervised clustering method to pinpoint subgroups based on individual omics systems, successfully identifying three distinct groups of breast cancer patients and linking specific genes to disease progression [13]. In a separate study by He et al., researchers concentrated on discovering cancer-selective combinatorial therapies for ovarian cancer by using supervised ML algorithms. They analyzed genomic and expression data from ovarian cancer patients along with pan-cancer markers to predict drug targets and mutations, ultimately identifying the most promising drug combinations with high accuracy, which may offer potential therapeutic options for personalized treatment [14]. Vipin et al. introduced a healthcare monitoring system that utilizes edge AI and the Internet of Things (IoT) for real-time patient scheduling and prioritization of resource allocation based on patients' conditions. This system gathers and transmits data while activating suitable actions on connected devices, thereby streamlining the monitoring process and support delivery. This capability is especially beneficial for elderly or disabled individuals and during pandemic scenarios [15]. A machine learning method demonstrated a greater accuracy in predicting cardiac arrest within 24 hours compared to conventional modified early warning scores for critically ill patients in the emergency department [16]. In a retrospective cohort study conducted by Antunes et al., the newly developed Chronic Liver Failure Consortium Acute Decompensation Score (CLIF-C ADs) machine significantly outperformed traditional models in predicting 30-day mortality [17]. Additionally, remote patient monitoring (RPM) has seen a rise in adoption in the aftermath of the COVID-19 pandemic [18]. In research conducted by Dong et al., comprehensive pharmacogenomics analyses were performed on over 1,000 cell lines to understand the mechanisms that influence the responses to anticancer drugs. The study involved the development and assessment of an advanced support vector machine (SVM) model, which used genomic data to effectively predict the sensitivity of various anticancer treatments [19].

Looking forward, AI technology is poised to achieve even greater advancements in the medical field. For example, drones could be used to transport medicine or provide aid to injured individuals. AI can also contribute to drug development, making the process more efficient. I believe that in the future, AI technology will be applied to gene therapy, potentially improving disease cure rates. As AI continues to evolve, its applications in the medical field will become even more widespread.

7 Intelligent medical and medical robots

Medical robots are a key application of artificial intelligence in healthcare. These robots integrate sensing, decision-making, action, and feedback into a complete closed-loop system and can be classified into navigation control systems, motion control systems, visual recognition control systems, and operational control systems. Surgical robots, in particular, must meet different requirements depending on the soft and hard conditions of tissues and organs, leading to the development of specialized "single-discipline surgical robots." For example, orthopedic surgical robots can accurately locate lesions, and with the help of imaging and video navigation, they can remove them in real time with precision. In procedures such as "bone replacement implant" surgeries, these robots require high levels of positioning accuracy, seamless human-machine coordination, and highly sensitive feedback to ensure success [20]. During the prevention and control of COVID-19, medical sampling robots were initially used for large-scale nucleic acid and blood sampling. Previously, most sampling was done manually, which involved a heavy workload with repetitive tasks and posed a high risk of infection for both healthcare workers and patients. Sampling robots, equipped with robotic vision, can accurately identify and locate appropriate sampling sites. By using force feedback sensors, these robots apply controlled force during the sampling process. This technology not only ensures the effectiveness of the sampling but also significantly reduces the risk of virus transmission and infection [21].

Additionally, puncture robots can minimize the influence of subjective factors, reduce labor intensity, and decrease patient exposure to radiation through precise image positioning. This greatly enhances surgical efficiency and accuracy while lowering the risk of injuries. Medical radiotherapy surgery robots are capable of placement from multiple angles and joints, significantly improving placement accuracy, flexibility, and spatial occupancy, thereby ensuring the effectiveness and speed of the entire radiotherapy procedure.Currently, complex surgeries require extensive learning time and high costs [22]. For an intern doctor aspiring to become a qualified and skilled chief surgeon, a significant number of surgical drills and practical training is necessary. Medical surgical robots can significantly shorten the time required for surgical training, enhance learning efficiency for interns, and help doctors achieve standardized surgical operations more quickly. The field of medical robots is evolving rapidly, with exciting clinical trial applications emerging worldwide every day. Standardizing the development and control of medical robot usage while avoiding potential risks is essential for us to consider and learn about continuously in the future.

8 Discussion

This study examines the significant role of artificial intelligence (AI) and machine learning (ML) algorithms in enhancing various aspects of modern healthcare. AI has become instrumental in transforming fields such as medical imaging, clinical decision-making, pathology, and minimally invasive surgery. The increasing availability of large-scale medical datasets and the continuous refinement of AI algorithms have accelerated the integration of these technologies into clinical practice, paving the way for improved diagnostic accuracy, treatment planning, and patient outcomes.

In medical imaging, AI-powered tools have shown remarkable efficiency in analyzing vast amounts of complex data, identifying patterns, and providing accurate diagnoses. These algorithms are capable of detecting anomalies in imaging data more quickly and accurately than traditional methods, significantly improving the early diagnosis of conditions such as cancer, cardiovascular diseases, and neurological disorders. The application of AI in medical imaging has enabled healthcare providers to reduce human error and improve the overall quality of care, resulting in better patient outcomes.

Similarly, AI-based clinical decision support systems have become valuable tools for physicians. These systems analyze patient data, including medical history and current health status, to offer personalized treatment recommendations. By leveraging machine learning algorithms, these systems can evaluate complex data points and present insights that assist healthcare professionals in developing more effective, individualized treatment plans. This personalized approach to healthcare is especially beneficial for managing chronic diseases, where continuous monitoring and tailored interventions can significantly improve patient outcomes.

Intelligent medical robots, such as the Da Vinci Surgical Robot, have revolutionized the field of minimally invasive surgery. These robots provide surgeons with enhanced precision, control, and visibility, allowing for more accurate and less invasive procedures. The three-dimensional vision systems integrated into these robots enable surgeons to perform delicate surgeries with greater accuracy, reducing the risk of complications and accelerating patient recovery. The Da Vinci Surgical Robot has demonstrated its ability to enhance surgical outcomes in fields such as urology, thoracic surgery, and general surgery, making it an essential tool in modern surgical practices.

AI also plays a critical role in drug discovery, where machine learning models are used to rapidly search vast databases for potential therapeutic compounds. These algorithms can predict the efficacy of compounds, accelerating the traditionally time-consuming and costly process of drug development. AI's ability to identify promising drug candidates with greater speed and accuracy has the potential to transform pharmaceutical research, particularly in fields such as oncology and infectious diseases, where timely drug development is critical.

Pathology is another area significantly impacted by AI technologies. Machine learning algorithms can assist pathologists by analyzing histopathological slides, identifying malignancies, and offering more accurate diagnoses. The automation of these processes reduces the burden on pathologists and minimizes the potential for human error, ultimately improving the efficiency and accuracy of pathology workflows. This is particularly beneficial in cancer diagnosis, where early and precise detection of malignant cells is crucial for determining appropriate treatment strategies.

Despite these advancements, the implementation of AI in healthcare is not without challenges. One major concern is data privacy, as AI systems require large amounts of sensitive patient information to function effectively. Ensuring the security and confidentiality of patient data remains a critical issue that healthcare organizations must address. Furthermore, the potential for algorithmic bias presents a significant challenge, as biased data could lead to unequal treatment outcomes for different patient populations. The "black box" nature of some AI models also raises concerns about transparency and interpretability, making it difficult for healthcare providers to fully trust AI-driven decisions. This lack of explainability in AI systems underscores the need for developing more interpretable models that clinicians can rely on with confidence.

Ethical considerations, including patient consent and the responsible use of AI, are also important aspects that must be addressed to ensure the widespread adoption of AI in healthcare. As AI systems become more integrated into medical practice, it is essential to establish clear ethical guidelines and regulatory frameworks to govern their use. These frameworks should focus on ensuring fairness, accountability, and transparency in AI applications to maintain patient trust and safeguard public health.

In conclusion, AI and machine learning algorithms are transforming healthcare by offering significant improvements in diagnostics, surgical precision, clinical decision-making, and drug discovery. These technologies have the potential to revolutionize patient care, but their successful implementation requires careful attention to challenges related to data privacy, algorithm bias, and ethical considerations. As AI continues to evolve, it is poised to play an increasingly important role in shaping the future of medicine, offering new possibilities for improving healthcare outcomes and enhancing the quality of patient care.

9 Limitation

Despite the promising advancements of AI in healthcare, this study has several limitations. Data privacy is a key concern, as large amounts of sensitive patient information are needed for AI systems to function. Additionally, algorithmic bias, the lack of transparency in AI models, and the challenges in generalizing results to real-world settings hinder wider adoption. The cost of implementing AI technologies also raises concerns about equitable access. These limitations highlight the need for further research to ensure that AI systems are secure, unbiased, and accessible across diverse healthcare settings.

10 Conclusion

Artificial intelligence (AI) and machine learning algorithms have brought significant advancements to healthcare, especially in diagnostics, treatment planning, and surgical procedures. Technologies like the Da Vinci Surgical Robot and AI-based diagnostic tools have demonstrated their potential to improve accuracy, efficiency, and patient outcomes. However, as with any rapidly evolving field, there are risks and challenges, such as data privacy, algorithm bias, and accessibility, that must be addressed to fully integrate AI into medical practice. Ethical guidelines and legal frameworks will play a crucial role in ensuring the responsible use of these technologies. As AI continues to evolve, its contribution to healthcare will likely grow, paving the way for more precise and personalized medical care.

Conflicts of interest

The authors declare that they have no conflict of interest.

References

[1] Butcher CJ, Hussain W. Digital healthcare: the future. Future Healthcare Journal. 2022, 9(2): 113-117. https://doi.org/10.7861/fhj.2022-0046

[2] Siriwardhana Y, Gür G, Ylianttila M, et al. The role of 5G for digital healthcare against COVID-19 pandemic: Opportunities and challenges. Ict Express. 2021, 7(2): 244-252. https://doi.org/10.1016/j.icte.2020.10.002

[3] Shakeel T, Habib S, Boulila W, et al. A survey on COVID-19 impact in the healthcare domain: worldwide market implementation, applications, security and privacy issues, challenges and future prospects. Complex Intell Systems, 2023, 9(1): 1027-1058. https://doi.org/10.1007/s40747-022-00767-w

[4] Lee SM, Lee D. Opportunities and challenges for contactless healthcare services in the post-COVID-19 Era. Technological Forecasting and Social Change. 2021, 167120712. https://doi.org/10.1016/j.techfore.2021.120712

[5] Delaney CW, Weaver C, Sensmeier J, et al. Nursing and Informatics for the 21st Century-Embracing a Digital World, -Book 2: Nursing Education and Digital Health Strategies. Chapter: Book Name. 2022 of publication, CRC Press. https://doi.org/10.4324/9781003281009

[6] Mistry C, Thakker U, Gupta R, et al. MedBlock: An AI-enabled and blockchain-driven medical healthcare system for COVID-19. IEEE. 2021: 1-6. https://doi.org/10.1109/ICC42927.2021.9500397

[7] Ng R, Tan KB. Implementing an Individual-Centric Discharge Process across Singapore Public Hospitals. International Journal of Environmental Research and Public Health. 2021, 18(16): 8700. https://doi.org/10.3390/ijerph18168700

[8] Wang F. On Future Computers and Computer Technology. Journal of Practical Medical Technology. 2006, 13(11): 1981-1982.

[9] Cao N. Big data technology and its application in the medical field. Engineering technology research. 2016, 5: 54-55.

[10] Jia Z, Ma X, Ai X, et al. The advantages of da Vinci robotic surgery system in urological surgery. Modern Journal of Urology. 2018, 23(5): 328-331.

[11] Álvarez-Machancoses Ó, DeAndrés Galiana EJ, Cernea A, et al. On the Role of Artificial Intelligence in Genomics to Enhance Precision Medicine. Pharmacogenomics and personalized medicine. 2020, 19(13): 105-119. https://doi.org/10.2147/PGPM.S205082

[12] Liu P, Lassén E, Nair V, et al. Transcriptomic and Proteomic Profiling Provides Insight into Mesangial Cell Function in IgA Nephropathy. Journal of the American Society of Nephrology. 2017, 28(10): 2961-2972. https://doi.org/10.1681/ASN.2016101103

[13] Vural S, Wang X, Guda C. Classification of breast cancer patients using somatic mutation profiles and machine learning approaches. BMC systems biology. 2016, 10(Suppl 3): 62. https://doi.org/10.1186/s12918-016-0306-z

[14] He L, Bulanova D, Oikkonen J, et al. Network-guided identification of cancer-selective combinatorial therapies in ovarian cancer. Brief Bioinform. 2021, 22(6): bbab272. https://doi.org/10.1093/bib/bbab272

[15] Rathi VK, Rajput NK, Mishra S, et al. An edge AI-enabled IoT healthcare monitoring system for smart cities. Computers & Electrical Engineering. 2021, 96: 107524. https://doi.org/10.1016/j.compeleceng.2021.107524

[16] Shaik T, Tao X, Higgins N, et al. Remote patient monitoring using artificial intelligence: Current state, applications, and challenges. Wiley Interdisciplinary Reviews: Data Mining and Knowledge Discovery. 2023, 13(2): e1485. https://doi.org/10.1002/widm.1485

[17] Antunes AG, Teixeira C, Vaz AM, et al. Comparison of the prognostic value of Chronic Liver Failure Consortium scores and traditional models for predicting mortality in patients with cirrhosis. Gastroenterología y Hepatología (English Edition). 2017, 40(4): 276-285. https://doi.org/10.1016/j.gastre.2017.03.012

[18] Mantena S, Keshavjee S. Strengthening healthcare delivery with remote patient monitoring in the time of COVID-19. BMJ Health & Care Informatics. 2021, 28(1).
https://doi.org/10.1136/bmjhci-2020-100302

[19] Dong Z, Zhang N, Li C, Wang H, Fang Y, Wang J, Zheng X. Anticancer drug sensitivity prediction in cell lines from baseline gene expression through recursive feature selection. BMC cancer. 2015, 15: 1-2.
https://doi.org/10.1186/s12885-015-1492-6

[20] Xie N, Cao Q, Wang J. Research on control points of medical robots. China Medical Device Letter. 2022, 28(12): 1-4.

[21] Zhuang Y, Ding H, Liu H, et al. The application and development of non-contact medical robots under the background of the epidemic. Advances in Biomedical Engineering. 2021, 42(1): 6.

[22] Liu Y, Han X, Tian W. Research status and prospect of medical robots in my country. Journal of Orthopedic Clinic and Research. 2018, 3(4): 193-194.