

## CURRENT TRENDS IN THE USE OF ARTIFICIAL INTELLIGENCE (AI) FOR COMPUTER-BASED DESIGN OF GARDEN AND PARK OBJECTS

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### **Current Trends in The Use of AI For Computer-Aided Design of Gardens and Parks**

Artificial intelligence is radically changing the approach to the design and management of landscape facilities. Modern AI technologies offer innovative solutions for creating efficient and aesthetically appealing green spaces.

Key areas of application of AI in landscape design:

- Analysis of geographical and climatic data.
- Optimization of spatial planning.
- Automation of care processes.
- Creating 3D models.
- Forecasting development trends.

Due to meticulous analysis of vast data arrays, artificial intelligence ensures a considerable acceleration of the design process, which allows for making genuinely optimal and well-reasoned decisions. AI systems can take into account hundreds of parameters, from soil type to local climate.

Advantages of using AI in landscape design:

- *Improving design efficiency*
- Reduction of development time.
- Cost reduction.
- Improving design quality.
- *Resource optimization*
- Rational use of water.
- Energy efficiency.
- Optimal selection of materials.
- *Environmental sustainability*
- Reducing environmental impact
- Supporting biodiversity.
- Adaptation to climate change.

AI is actively used to create "smart gardens", where automation systems control watering, lighting and nutrient application. The application of machine learning technologies opens up opportunities for the accurate prediction of diverse plant needs, including water, nutrients, and lighting, and allows for the optimization of their care strategies based on the data obtained. "Artificial intelligence is not a replacement for human creativity, but a powerful tool for enhancing it in landscape design". In general, there are several features of the use of AI in landscape design:

#### 1. Intelligent mechanisms are shaping a new era of landscape design.

In the context of big data processing, artificial intelligence demonstrates impressive capabilities in processing colossal volumes of information, which encompasses diverse geographic parameters, key climate features, important environmental factors, as well as a broad spectrum of other variable data. This allows designers to make decisions based on deep analysis, relying on complex databases.

Visual image recognition. Using deep learning technologies, AI can analyze images and video, helping landscape designers assess existing green spaces in more detail. This allows for more accurate and informed decisions about plant placement, zoning, and ecological adaptation of the environment.

Optimization of spatial solutions. The use of optimization algorithms makes it possible to use the territory as efficiently as possible, ensuring the harmonious coexistence of natural and artificial elements, such as trees, paths, recreation areas, etc.

Careful plant selection with detailed consideration of environmental features. AI analyzes climatic and soil conditions, allowing you to select the most adapted plant species that will ensure the sustainability and biodiversity of the landscape.

Economical use of resources. Through conducting a thorough and comprehensive analysis of data on water, energy, and material consumption, artificial intelligence contributes to achieving a significant reduction in operational costs and tangibly reducing the negative impact on the environment.

#### 2. Benefits of integrating AI into landscape design.

Reduction of time and financial costs. Thanks to fast data processing, artificial intelligence allows you to reduce the laboriousness of the design process and significantly save the budget.

With the aim of consistently improving the quality of various projects, artificial intelligence effectively analyzes colossal volumes of diverse information, providing developers with the opportunity to make informed decisions based on objective data, which, as a consequence, leads to a significant increase in the quality of projects being implemented.

Enhancing creative potential. While artificial intelligence cannot completely replace human creativity, it significantly expands its boundaries, offering innovative ideas and unconventional solutions.

### 3. Smart Gardens: Synthesis of Nature and Advanced Technology.

Implementation of automated care: Artificial intelligence is actively being integrated into advanced smart garden systems, carrying out comprehensive control of watering, providing plants with essential nutrients, and even offering them protection from pests, creating optimal conditions for their growth and development.

Monitoring and analysis of the condition of green spaces. Smart systems controlled by artificial intelligence monitor plant health and timely notify about the need for intervention.

Rationalization of resource use. By analyzing environmental parameters, artificial intelligence helps to use water, light, and fertilizers more efficiently, contributing to sustainable development.

### 4. Considering the key role of artificial intelligence and the future prospects for the development of landscape design.

Trend analysis and forecasting. AI analyzes previous projects and consumer preferences, identifying new trends and predicting future directions for landscape architecture.

Creating interactive 3D models. Thanks to the utilization of advanced neural networks, contemporary designers gain the ability to create exceptionally realistic photorealistic models, which provides them with a valuable tool for pre-evaluating the final appearance of the project being developed and making necessary adjustments at the initial stages.

### 5. Challenges in integrating artificial intelligence.

The need for retraining specialists. To ensure the most effective application of artificial intelligence, there is a primary necessity for training highly qualified specialists capable of harmoniously combining in-depth knowledge in the field of landscape design with advanced digital technologies.

Data security and confidentiality. Processing large amounts of information requires the implementation of strict security standards to avoid risks of data leakage.

Harmonizing human-machine interaction. Effective collaboration between designers and AI requires clear synchronization of processes so that technology becomes an assistant, not a replacement, for human talent.

Innovative areas of development:

- Biophilic design with the integration of natural elements.
- Vertical gardening for efficient use of space.
- Smart plant health monitoring systems.
- Automated solutions for garden care.

Forecasts for the 2030s predict further development of AI technologies in horticulture:

- Regenerative gardening.
- Climate-adaptive solutions.

Through advanced research and technology, AI overcomes the limitations of traditional approaches, increasing the accuracy and efficiency of decision-making. The designer's artistic vision is based on his life experience, worldview, personal qualities and creative achievements. Cultural context has always played an important role in art, but today the amount of information available to humans is significantly inferior to the capabilities of computer systems.

Modern expert systems simulate the thinking process of specialists, analyzing complex issues and suggesting optimal solutions, and the use of artificial intelligence technologies contributes to increasing accuracy in the design process, which allows designers to quickly adapt their ideas to specific conditions. In addition, modern algorithms can imitate human emotions, which makes the process of creating a harmonious landscape more intuitive.

AI in landscape analysis and planning.

One of the key areas of AI application in landscape design is analysis and planning. Thanks to machine learning algorithms, designers can accurately process data about the environment, including relief, soil composition, climatic features and vegetation types. This helps to create informed solutions that meet the specific needs of the territory.

Additionally, AI algorithms can predict the long-term impacts of design decisions by analyzing aspects such as water balance, biodiversity, and carbon footprint, allowing designers to create sustainable and environmentally efficient landscapes.

Increasing creativity and innovation.

AI does not replace human creativity, but rather augments it. Generative algorithms can suggest multiple design options based on given criteria, allowing designers to experiment with new concepts. Modern artificial intelligence platforms, among other features, provide comprehensive support for innovative virtual reality (VR) and augmented reality (AR) tools, which unlocks a unique opportunity for clients to visually review developed projects and actively interact with them in a fully digital environment directly at the design stage.

Automated 3D design.

Modern technologies of artificial intelligence, 3D modeling, and visualization have gained widespread application in diverse industries and fields of activity, including, in particular, such an important field as landscape design. The application of computer-aided design (CAD) systems based on artificial intelligence opens up the possibility for contemporary designers to create not only accurate but also intuitive and user-friendly project layouts.

Using deep learning and computer vision algorithms, AI systems can automatically recognize and generate 3D models, adapting them to design requirements. Such technologies are used in urban planning, park and garden design, architectural design, and other fields. They also help beginners and students of landscape architecture to master professional skills faster.

Innovative visualization technologies unlock amazing opportunities for the transformation of traditional two-dimensional sketches into volumetric three-dimensional models, which, undoubtedly, significantly enhances the overall perception of the future project as a whole. Moreover, they also actively contribute to establishing more effective and productive communication between designers, clients, and the entire working team, which, in turn, helps to prevent the occurrence of potential errors and ensures the high quality of the final implementation of the conceived idea.

Despite its significant potential, integrating AI into landscape design has its challenges. One of the main issues is the ethical aspect: overuse of AI can diminish the value of human creativity. It is important that AI remains a supporting tool, not a replacement for the role of the designer.

There are also technical difficulties, particularly related to data quality and possible algorithmic biases. To avoid this, it is necessary to critically evaluate input information and improve forecasting models.

In the very near future, artificial intelligence in the field of landscape design will transform into an even more powerful and multifunctional tool through close integration with advanced predictive analytics systems, innovative parametric modeling, and the continuous acquisition of real-world feedback, which will make it possible to create not only aesthetically pleasing but also maximally adapted to changing conditions and truly ecologically sustainable landscape spaces.

Additionally, open source platforms and cloud services will make AI technologies more accessible to a wider range of users, including civil society organizations, enabling a more inclusive and environmentally responsible approach to urban design.

The introduction of AI into landscape design is changing the way we create our environments. By harnessing the computational power of algorithms, designers can improve the efficiency and quality of their designs while addressing social and environmental challenges. Successful integration

of AI will require not only technical improvements, but also ethical and social awareness of its impact. Thus, the landscape design of the future will not only be functional and beautiful, but also a tool for positive change in society and nature.

### **The Impact of Artificial Intelligence on The Diversity of Plant Design in Landscape Architecture.**

Artificial intelligence (AI) is transforming various industries, including landscape design, by offering innovative tools to expand the possibilities of plant selection and application. The main areas of AI impact are:

- **Plant Selection:** Algorithms analyze soil, sunlight, climate data, and aesthetic preferences, helping designers create more diverse landscape compositions.
- **Biodiversity conservation:** AI promotes the inclusion of native, rare, or endangered species in projects, maintaining ecological balance.
- **Design optimization:** Artificial intelligence systems model changes in plant composition over time, taking into account seasonal variations and the environment.
- **Data-driven design:** Analyzing previous projects allows you to determine which plants are best adapted to specific conditions.
- **Generative design:** Intelligent algorithms in automatic mode generate diverse options for compositional solutions, which actively stimulates the conduct of creative experiments and facilitates the implementation of innovative ideas.
- **Intelligent adaptive systems:** Landscape solutions driven by artificial intelligence are characterized by the ability to flexibly and dynamically change in response to constant climate changes, thanks to the application of a complex of modern sensors and constantly updated data arriving in real time.
- **Inclusivity:** AI helps create accessible and comfortable spaces, taking into account the needs of different user groups.

Using AI in water resources management.

Through the analysis of large volumes of data and accurate forecasting, AI plays a key role in water management. The combination of geographic information systems (GIS) and AI allows you to optimize water resources management processes. Main stages of application:

1. **Predictive modeling:** AI assesses flood risks, water quality, and water consumption by integrating this data into GIS.
2. **Real-time monitoring:** Sensors and satellite imagery allow you to track weather conditions, water quality, and flow levels.
3. **Data integration:** AI combines information from different sources to gain a more complete picture of the state of water resources.
4. **Decision-making:** In the context of making critical management decisions, the application of comprehensive analytics plays a key role, helping to develop detailed scenarios and effective strategies for water resource management.
5. **Optimize resource allocation:** In the context of the efficient use of water resources, the application of advanced artificial intelligence algorithms ensures a noticeable increase in the efficiency of water usage for agricultural irrigation and meeting various other needs.

### **AI in Landscape Nutrient Management.**

Artificial intelligence helps optimize plant health and landscape resilience through the following mechanisms:

- **Soil analysis:** Determining nutrient levels and selecting optimal fertilizers.
- **Smart Fertilization:** Taking into account fluctuating weather conditions, specific stages of plant growth and development, as well as their individual needs for precise dosing of mineral fertilizers.
- **Forecasting nutrient needs:** Using historical data to prevent nutrient deficiencies or excesses.



- Precise nutrient delivery: Automated fertilizer application based on soil conditions and plant needs.
- Remote sensing monitoring: Using satellites and drones to assess plant health and detect nutrient deficiencies.
- Decision support: Data analysis to develop effective fertilization strategies.
- Learning and improvement: AI adapts to changes in the environment, improving its recommendations over time.

Artificial intelligence opens up new possibilities for landscape design and resource management. Its application significantly contributes to the maintenance of environmental sustainability, the conservation of biological diversity, a more efficient allocation of available resources, and the overall optimization of plant care. The integration of AI into these areas makes landscape projects not only more aesthetic, but also functional and environmentally responsible.

### **The Role of Artificial Intelligence in The Fight Against Diseases and Pests.**

Due to the rapid advancement of modern computer technologies, and particularly the progress in the field of artificial intelligence, there is a pronounced transition towards the implementation of automated expert systems in the critical area of plant disease and pest control, as well as in ensuring precise and highly efficient harvesting. Innovative information and communication technologies, such as wireless sensor networks, modern drones, high-precision GPS systems, user-friendly mobile applications, timely SMS messages (including USSD and voice services), informative web portals, and also RSS feeds, have fundamentally changed traditional approaches to monitoring the spread of diseases and pests, as well as in the process of advising gardeners and farmers.

Social media has created a convenient platform for farmers to interact with experts and receive real-time advice. Leading global IT corporations are actively developing innovative solutions for the agricultural sector, utilizing advanced artificial intelligence technologies for comprehensive support of the process of making informed decisions in the field of horticulture. Artificial intelligence plays an exceptionally important role in the effective fight against pests and various plant diseases, providing, in particular, the following:

- Early detection – Innovative systems powered by artificial intelligence conduct an in-depth analysis of diverse data, including digital images, current climatic conditions, and accumulated historical metrics, with the aim of promptly detecting the very first signs of disease development or the appearance of harmful insects, which ensures the possibility of a rapid response and a tangible reduction of potential damage.
- Accurate diagnosis – by analyzing plant images, artificial intelligence is able to recognize diseases and insect infestations, suggesting effective treatment methods.
- Risk prediction – AI algorithms analyze environmental factors such as temperature, humidity, and precipitation to predict potential disease outbreaks and to develop a set of preventive measures.
- Improvement of treatment methods - by conducting a thorough analysis of the effectiveness of various control methods, artificial intelligence proposes the most optimal treatment options, while taking into account various factors, including financial costs, potential environmental impact, and a range of other important variables.
- Targeted application of protection products – robotic drones and intelligent systems allow for more precise application of pesticides and similar products, which reduces their consumption and positively impacts the ecology.
- Data-driven decision-making – Using information from various sources, intelligent systems help gardeners make more informed decisions to ensure plant health.
- Continuous monitoring – Artificial intelligence systems continuously monitor changes in plant health and, based on the information obtained, adapt pest control approaches in real-time.

- To minimize the harmful impact on the environment, through the precise and judicious application of chemical agents, AI systems are instrumental in maintaining the delicate balance of ecosystems, which is of paramount importance.

In conclusion, the implementation of artificial intelligence technologies within the realm of combating diseases and pests not only reduces risks and boosts yields but, crucially, also supports the health of orchard cultivations, all achieved through the application of exceptionally precise and effective methodologies.

### **The Use of Robots in Landscape Management.**

Intelligent robots, equipped with advanced artificial intelligence technologies, are playing an increasingly crucial role in the modern field of landscape management. These robots are capable of effectively adapting to diverse environmental changes, rapidly analyzing large volumes of information, and making independent decisions. Autonomous vehicles, industrial and service robots, as well as drones, are just some of the numerous systems that utilize sophisticated artificial intelligence algorithms to process data obtained from a variety of sensors and surveillance cameras.

The main advantages of robots in landscape management:

- Increased labor efficiency – automating labor-intensive processes such as mowing, pruning, or weeding reduces the need for manual labor.
  - Cost reduction – although the initial investment may be significant, in the long run the works reduce operating costs.
  - High accuracy in task performance – robots ensure consistent and uniform task performance, which is important for landscape maintenance.
  - Environmental safety – using electric robots reduces CO<sub>2</sub> emissions and the need to use chemicals.
  - 24/7 operation – unlike humans, robots can work without interruption, allowing for continuous service of territories.
  - Increased safety – automating dangerous tasks, such as pruning trees or working on steep slopes, reduces the risk of injuries.
  - Data monitoring and analysis – robots can collect information about soil condition, moisture levels, and plant health to optimize care.
  - Scalability – robotic systems can be used both in private gardens and in large-scale park areas.
- Examples of using robots in landscape maintenance:
- Robotic lawn mowers are autonomous systems that operate along a set route, avoid obstacles, and provide a high-quality lawn cut.
  - Automated weeding – AI-powered robots identify weeds and remove them, reducing the need for herbicides.
  - Plant pruning robots – recognize the shape and condition of plants, perform precise pruning to improve their growth.
  - Robotic planting systems are automated solutions for planting seeds, seedlings or bulbs with high precision.
  - Systems for applying fertilizers and pesticides are autonomous robots that analyze the condition of plants and apply the necessary preparations in a dosed manner.

- Monitoring work - to ensure proper care, the monitoring process includes the systematic collection of diverse data, including information on the overall condition of plants, current humidity levels, as well as other key factors that directly affect the health and productivity of the garden.

Overall, the introduction of robotic technologies into landscape management allows for increased care efficiency, reduced costs, and reduced environmental impact, ensuring the sustainability and durability of landscape systems.

Robotics in landscape maintenance. Using robots for tree pruning and planting. Autonomous robots that perform tree trimming or planting functions face numerous challenges in the field of

horticulture. Landscape features such as uneven terrain, dense green cover, and a variety of objects create significant obstacles for computer vision algorithms. Dynamic environmental changes caused by seasonal fluctuations and natural plant growth complicate the process of navigation and accurate task performance.

Fluctuating lighting conditions, which vary based on the time of day and weather patterns, significantly impact color perception and the overall performance of computer vision systems. Furthermore, robotic systems themselves actively modify their surroundings during operation, for instance, by performing pruning of bushes and trees. This dynamic alteration of the landscape considerably complicates the process of timely updating of terrain maps, which are essential for effective navigation. Robots must navigate diverse and challenging terrain conditions, including grassy areas, sidewalks, and various obstacles such as gravel or wood chips. Moreover, the complexity of precisely modeling plant shapes, particularly ornamental plantings, necessitates the development of highly accurate algorithms for correct pruning and effectively maintaining the desired shape.

One of the primary challenges lies in the accurate comparison of actual plant shapes with desired ones, while it's crucial to consider various geometric constraints, as well as to leverage in-depth expert knowledge regarding plant care. Furthermore, the process of precisely guiding cutting tools to a designated point is additionally complicated by the inherent flexibility of the plants and the noticeable influence of diverse external factors, such as, for instance, gusts of wind.

Expert systems for landscape management. While artificial intelligence has already made an undeniable significant impact on landscape design, its application in the field of landscape maintenance is still quite limited. The implementation of intelligent systems in landscape maintenance practice faces a number of the following challenges and difficulties:

- Response time and accuracy. Key factors that determine the effectiveness of an expert system are, undoubtedly, the speed of its functioning, and also, no less importantly, the high accuracy of the results obtained. Delays in response or insufficient accuracy can affect the user's choice of certain landscape maintenance strategies.
- Data volume: One of the key obstacles on the path to the effective implementation of intelligent systems is the necessity to process colossal volumes of data in real-time. Furthermore, a critically important task becomes the filtering and sifting out of secondary information, which, undoubtedly, significantly complicates their practical realization.
- Execution Methodology: Using big data requires effective learning and information retrieval methods to achieve optimal performance.
- Data cost: Most AI systems operate over the internet, which limits their use in remote areas.
- System flexibility. Reliable intelligent solutions must easily adapt to changing environmental conditions.

The integration of artificial intelligence in landscape care opens up prospects for automating processes and increasing efficiency, including:

- At the heart of the concept of autonomous landscape management lies the application of advanced artificial intelligence algorithms to carry out so-called predictive, or prognostic, maintenance. This approach involves in-depth analysis of data coming from various sensors that record environmental conditions, as well as a thorough study of accumulated historical records. The goal of this is not only the rapid detection, but also, and more importantly, the effective prevention of potential problems, such as the spread of pests, the occurrence of plant diseases, or unforeseen malfunctions in irrigation systems, which ultimately contributes to a significant increase in the efficiency and sustainability of landscape management..
- Carefully developed personalized landscape design projects are intended to take into account a wide range of factors, including, first and foremost, the unique environmental conditions of a specific site, the client's individual aesthetic preferences, as well as clearly defined functional requirements for the future landscape space.



- Active support for biodiversity and effective ecosystem restoration is achieved through intelligent systems based on artificial intelligence. These systems are capable of carrying out comprehensive monitoring of both plant and animal populations, timely detecting invasive species, and accurately identifying areas that require priority protection and restoration to preserve natural harmony.

- Digital assistants for gardening are user-friendly chatbots and mobile applications that provide users with valuable personalized recommendations for plant care, as well as prompt troubleshooting of various problems that may arise in the gardening process.

Overall, the progressive development of artificial intelligence technologies significantly contributes to the creation of not only more sustainable and environmentally safe, but also exceptionally functional landscapes. This, in turn, promotes the enrichment of the natural environment as a whole and, undoubtedly, improves the quality of life for entire communities.

### **Choosing Plants Taking Into Account Climate and Soil.**

Artificial intelligence is revolutionizing the process of selecting plants for landscaping through sophisticated data analysis algorithms. Modern AI systems analyze over 50 soil and climate parameters to create optimal plant combinations.

Algorithmic plant selection includes:

- Analysis of soil pH and its mineral composition.
- Estimate the annual precipitation level.
- Study of temperature fluctuations.
- Research on the level of solar activity.
- Taking into account wind loads.

Integrating native plant species into garden design plays a crucial role in shaping ecologically sustainable and self-renewing ecosystems, which is exceptionally important for maintaining the natural balance and preserving the environment. Systems that utilize artificial intelligence are capable of effectively identifying specifically those native plant species that:

1. Requires less care and resources.
2. Support local fauna.
3. They maintain the natural balance of the ecosystem.
4. Adapted to local climatic conditions.

Modern sustainable gardening is based on AI recommendations to create viable garden spaces:

1. Grouping plants by water needs.
2. Creating multi-tiered plantings.
3. Using natural methods of pest control.
4. Introduction of seasonal crop rotation.

AI technologies allow for the creation of individual care plans for each plant, taking into account the specific conditions of the site. Artificial intelligence systems are constantly learning based on data from thousands of gardens, improving the accuracy of recommendations and plant growth predictions.

Smart algorithms also help create planting maps taking into account:

- Compatibility of species.
- Seasonality of flowering.
- Nutrient needs.
- Spatial location.

Artificial intelligence helps create sustainable garden compositions that require minimal human intervention and are as close to natural ecosystems as possible.

### **Plant Health Monitoring and Management Technologies.**

Modern artificial intelligence technologies allow you to create a "smart garden" where plant care is done automatically and with maximum efficiency, for which a number of automation tools have already been created [1].

Intelligent monitoring sensors:

- Soil moisture sensors measure water levels at different depths.
- Temperature sensors monitor the microclimate around the plants.
- UV sensors control the light level.
- pH meters analyze soil acidity.

Automated care systems:

- Smart irrigation systems are activated based on moisture data.
- Fertilizer dispensers operate on a schedule set by AI.
- Automatic lighting control for greenhouse plants.
- Ventilation systems maintain optimal temperatures.

Garden health analytics:

- AI analyzes data from all sensors in real time.
- Algorithms detect early signs of plant diseases.
- The system generates daily reports on the condition of each plant.
- The owner receives push notifications about critical changes.

Preventive measures:

- AI predicts potential problems based on historical data.
- The system provides recommendations for preventive measures.
- Automatic adjustment of care parameters prevents plant stress.
- Algorithms take into account seasonal changes and weather conditions.

The integration of these technologies creates a self-sufficient ecosystem where each plant receives individual care without constant human intervention. Artificial intelligence provides optimal conditions for plant growth and development, minimizing the risks of disease and stress.

### **Predicting Trends in Landscape Design Using AI.**

Artificial intelligence opens up new possibilities for predicting future trends in landscape design. AI systems analyze huge data sets that include:

- Historical design trends.
- User search queries.
- Social media activity.
- Data on sales of gardening materials.
- Climate change and its impact on landscape design.

Consumer feedback analysis has become a key factor in shaping future projects. In this case, AI allows you to quickly collect and process the following data sets:

- Comments on specialized forums.
- Reviews about implemented projects.
- Client requests to landscape designers.
- User reactions on social networks.

Based on this data, AI predicts an increase in demand for:

1. Vertical gardening for small spaces.
2. Biophilic design with the integration of natural elements.
3. Smart garden care automation systems.
4. Plants resistant to climate change.
5. Edible landscapes and urban gardens.

AI identifies changes in consumer behavior through analysis of:

- Demographic trends.
- Urbanization processes.
- Environmental awareness.
- Economic factors.

Artificial intelligence systems predict an increase in demand for multifunctional garden spaces that combine:

1. Recreation areas.
2. Places to grow food.
3. Natural habitats.
4. Technological solutions for garden care.

Integrating artificial intelligence into landscape design poses a number of industry-specific challenges. Data security is a critical issue when implementing AI technologies into landscaping projects.

Main data security issues:

- Protecting confidential customer information.
- Preservation of intellectual property of design solutions.
- Risks of unauthorized access to control systems.
- Vulnerability of sensor networks and IoT devices.

At the same time, training personnel requires significant resources and time; specialists must master:

1. Working with AI design tools.
2. Data analysis and interpretation of results.
3. Setup and maintenance of "smart" systems.
4. Integration of various technological solutions.

Barriers to adapting new technologies:

Psychological resistance to change among employees often slows down the implementation of innovations. Experienced professionals may be skeptical of AI solutions, preferring traditional working methods.

Financial challenges include:

- The high cost of AI hardware and software
- Staff training costs
- The need for constant system updates
- Investment in cybersecurity

Technical difficulties arise when:

1. Integration of various software platforms
2. Ensuring a stable internet connection
3. Adjusting the accuracy of AI algorithms
4. Adaptation of systems to local conditions

Successfully overcoming these challenges requires a systematic approach and phased implementation of technologies, taking into account the specifics of each project and the capabilities of the team.

Technological innovations are rapidly changing landscape design, creating new opportunities for gardening and urban greening. Forecasts for the 2030s show exciting prospects for the industry.

Predicted trends for the 2030s:

- Smart plant care systems - automated AI-based systems for monitoring plant health.
- Edible landscaping is the integration of food crops into the urban landscape.
- Regenerative gardening - a focus on soil restoration and carbon sequestration.
- Climate-adaptive gardening - sustainable solutions for extreme weather conditions.

Innovative spatial solutions. Vertical farms and gardens are becoming an answer to the limited urban space:

- Smart container gardens.
- Rooftop gardens with AI control.
- Vertical green walls with automated irrigation.
- Multi-tiered urban greenhouses.

Biophilic design. The biophilic approach combines natural elements with architecture:

- Integration of living plants into building facades.
- Creation of natural microecosystems.
- The use of organic shapes in design.
- Use of natural materials.

The humanistic aspect of gardening. Interaction with nature remains a key element of gardening:

Therapeutic practices:

- Sensory gardens.
- Meditative spaces.
- Community gardens.
- Green areas for rehabilitation.

Technology support:

- AI assistants for therapeutic gardening.
- Virtual garden tours.
- Personalized garden therapy programs.
- Monitoring the psychological impact of green areas.

Autopilot functions. Smart systems provide garden care during the owner's absence:

- Automatic watering.
- Pest monitoring.
- Lighting adjustment.
- Microclimate control.

The future of gardening is envisioned in a close integration of advanced technological innovations and refined natural aesthetics. Specifically, in landscape design, artificial intelligence technologies unlock entirely new perspectives for developing not only innovative, but also significantly more effective solutions compared to traditional approaches.

Key aspects of AI's impact on landscape design:

- Automation of routine design processes.
- Generation of creative design concepts.
- Optimizing the use of space and resources.
- Predicting plant growth and environmental impact.

Modern landscape architecture is confronted with the complex challenges of ever-increasing urbanization and the pressing need to create truly ecologically sustainable green spaces within urban environments. In these circumstances, artificial intelligence is becoming a reliable tool in addressing these crucial problems, utilizing the powerful capabilities of intelligent data analysis and innovative automated design. It's worth noting that artificial intelligence is fundamentally transforming the traditional approach to the process of creating both private gardens and large public parks. Let's examine in more detail the main promising trends that are already actively defining the future direction of modern landscape architecture.

1. Automated design of green areas:

- Generate multiple design options in minutes.
- Optimization of plant placement taking into account local conditions.
- Creating 3D visualizations of future projects.

2. Smart control systems:

- Automatic irrigation control based on soil moisture data.
- Monitoring plant health using computer vision.
- Forecasting needs for green space maintenance.

3. Environmental optimization:

- Analysis of the impact of projects on the local ecosystem.
- Calculating the carbon footprint of landscape solutions.
- Plant selection for maximum biodiversity.

Urbanization creates new challenges for landscape architects. AI helps find innovative solutions:

- Vertical gardening with automated care systems.
- Integrating "smart" elements into city parks.
- Creation of micro-parks in dense urban areas.

4. Innovations in design:

1. Using visitor traffic data to optimize routes.
2. Adaptive lighting based on user activity.
3. Integration of AR technologies to improve interaction with space.

5. Personalization of public spaces:

- Analysis of local community needs.
- Adapting the design to different age groups.
- Creation of multifunctional recreation areas.

Artificial intelligence technologies play a key role in the development of more ecologically sustainable and adaptive landscape solutions. Machine learning systems conduct in-depth analysis of diverse data, including information about climate conditions, soil type, and local flora, with the aim of optimizing design solutions. Thanks to this, it becomes possible to create spaces that are not only visually appealing and aesthetically refined, but also, and no less importantly, ecologically balanced and harmonious with the surrounding environment.

### **Basic Artificial Intelligence Technologies Used in Landscape Design.**

In contemporary landscape design, there is an active trend towards integrating three core artificial intelligence technologies: machine learning (ML), deep learning (DL), and computer vision (CV). These advanced technologies, which are foundational for numerous innovative solutions, are playing an increasingly important role in shaping effective and aesthetically pleasing landscapes of the future.

Machine learning in green space design. ML algorithms analyze large datasets of successful landscape projects and create optimized solutions for new spaces. You get:

- Automatic selection of plants taking into account climatic conditions.
- Forecasting the growth and development of green spaces.
- Optimization of irrigation and maintenance systems.
- Calculation of the optimal location of landscape elements.

Deep learning for creating innovative designs. DL systems are capable of generating unique design solutions based on given parameters:

- Creating 3D landscape models.
- Generation of territory planning options.
- Adaptation of existing designs to new conditions.
- Simulation of seasonal changes in the landscape.

Computer vision in spatial analysis. CV technologies transform visual data into practical solutions:

- Analysis of the topography of the area through aerial photography.
- Recognizing vegetation types and their condition.
- Creating accurate 3D maps of existing landscapes.
- Monitoring changes in the landscape in real time.

The practical application of these technologies allows for the creation of "smart" landscape designs. For example, a computer vision system analyzes the illumination of the site throughout the day and suggests the optimal location of plants with different needs for sunlight.

ML algorithms are already helping designers create sustainable ecosystems, taking into account the interaction of different plant species, soil characteristics, and climate factors. DL models generate land-use planning options that best meet user needs and environmental requirements.

The integration of these technologies creates new opportunities for automating routine tasks and improving project quality.

Generative networks are a new stage in the development of landscape design. This technology allows you to generate unique design solutions based on existing examples and given parameters.

Key features of GAN in landscape design:

- Creating realistic visualizations of future projects.
- Generation of planning options taking into account specified constraints.
- Adaptation of existing design solutions to specific conditions.
- Modeling seasonal landscape changes.

GAN analyzes thousands of examples of successful landscape projects and creates new concepts that meet aesthetic and functional requirements. The system takes into account terrain features, climatic conditions and environmental factors when generating design solutions.

Practical applications of GANs include [2]:

1. Visualization of various landscaping options.
2. Creation of 3D models of landscape compositions.
3. Forecasting plant growth and landscape changes.
4. Optimization of the placement of landscaping elements.

Integrating GANs into the workflow allows designers to quickly create and evaluate different layout options. The technology does not replace human creativity, but rather enhances it by providing tools for experimenting with shapes and compositions [3]. Benefits of using GANs:

- Reducing time for concept development.
- Ability to create an unlimited number of options.
- Taking into account the complex relationships between landscape elements.
- Increasing the realism of visualizations.

Modern GAN systems are capable of generating not only static images, but also dynamic models of landscape development, demonstrating what the area will look like a few years after the project is implemented.

The implementation of artificial intelligence in landscape architecture unveils a range of promising advantages while simultaneously posing certain challenges that must be considered. Undoubtedly, artificial intelligence technologies offer unique opportunities for developing environmentally responsible and sustainable landscape projects, which is crucial in today's world. Let's examine in more detail the key advantages, as well as potential difficulties, associated with the active implementation of these innovative technologies into the practice of landscape architecture.

Environmental benefits:

- Water resource optimization: AI systems analyze weather conditions, soil moisture, and plant needs to create effective irrigation schemes.
- Biodiversity: Algorithms help select optimal plant combinations to create sustainable ecosystems.

- Plant health monitoring: Computer vision systems detect diseases and pests at early stages.

Project management:

- Automating routine tasks: AI takes over technical calculations and documentation.
- Plant growth prediction: Algorithms model the development of green spaces over the years.
- Budget optimization: Systems analyze costs and offer cost-effective solutions.



Data quality:

- The difficulty of collecting reliable information about local conditions.
- The need for regular database updates.
- High cost of high-quality datasets.

User safety:

- Protection of personal data of park visitors.
- Cybersecurity of control systems.
- Risks of unauthorized access to project documentation.

Technical limitations:

- The need for a powerful computing infrastructure.
- Difficulty integrating with existing systems.
- The need for specialized training for staff.

Implementing AI requires a balance between innovation and preserving traditional approaches to landscape design. Successful integration of technology depends on the team's willingness to adapt to new working methods and the ability to solve technical challenges.

### **Modern Solutions For Landscape Management Using AI.**

Smart landscape management systems are transforming traditional methods of landscape maintenance. Artificial intelligence creates new opportunities for automating and optimizing green space maintenance processes.

Intelligent irrigation systems. Intelligent irrigation systems play a key role in modern landscape management:

- Real-time weather analysis.
- Automatic adjustment of the watering schedule.
- Optimization of water consumption.
- Soil moisture monitoring.
- System malfunction warning.

Monitoring the condition of vegetation. Sensors and sensors integrated with AI algorithms provide constant monitoring of the condition of vegetation:

- Detection of plant diseases at early stages.
- Monitoring the level of nutrients in the soil.
- Tracking plant growth rates.
- Determining the optimal time for pruning.
- Forecasting fertilizer needs.

Practical applications of AI systems. Practical applications of AI systems include:

1. Automated greenhouses with microclimate control.
2. Robotic lawn mowing systems.
3. Drones for monitoring large areas.
4. Mobile applications for landscape management.
5. Pest early warning systems.

The harmonious integration of these advanced technologies unlocks opportunities for creating a holistic ecosystem designed for effective landscape management. Artificial intelligence conducts a comprehensive analysis of data obtained from various sources of information, generates exhaustive recommendations based on this analysis, and, crucially, in automatic mode, promptly adjusts key plant care parameters. The implementation of such an intelligent approach ensures the creation of the most favorable and optimal conditions for the active growth and healthy development of plants, while simultaneously helping to achieve significant savings and minimize the consumption of various resources.

### **Innovative Technologies For Creating Landscaped Facilities of The Future**

Modern SMART solutions are radically changing the approach to the design and maintenance of landscaped facilities. Innovative technologies allow you to create more efficient and sustainable green spaces.

Key design innovations:

- *3D scanning of the territory*- the technology creates an exact digital copy of the landscape for further modeling.
- *Parametric design*- automates the process of creating complex geometric shapes and optimizes the placement of elements.
- *Virtual Reality (VR)*- allows you to visualize the future project on a real scale.
- *Augmented Reality (AR)*- overlays digital elements on real space for better planning.

Construction and maintenance automation:

- Robotic systems for planting plants.
- Autonomous lawn mowers with GPS navigation.
- Drones for monitoring the condition of green spaces.
- Systems for automatic collection and processing of fallen leaves.

Smart systems integration:

1. Adaptive lighting that responds to the presence of visitors.
2. Air quality and noise level sensors.
3. Rainwater harvesting systems with smart distribution.
4. Interactive information stands with AI assistants.

These mentioned advanced technological solutions are capable not only of significantly optimizing various work processes, but also, and particularly valuable, of opening up fundamentally new horizons for visitors regarding their full interaction with the surrounding natural environment. The implementation of intelligent systems, based on artificial intelligence, into the overall management system provides a unique opportunity to effectively predict and proactively prevent the occurrence of potential problematic situations, thereby ensuring the long-term stability and uninterrupted functioning of various facilities of garden and park designation.

On the path to the effective implementation of artificial intelligence in landscape architecture, a number of significant challenges arise, among which particularly stand out the need for obtaining high-quality data for training relevant models, the complexity of integrating cutting-edge technologies into existing workflows, as well as the pressing necessity for specialized knowledge and qualifications for fully working with artificial intelligence systems. One of the most substantial problems is precisely the need for large volumes of first-rate data necessary for training artificial intelligence models. It is critically important to ensure continuous access to accurate, representative, and reliable information, encompassing various aspects of landscapes, plant species, soil types, and other crucial factors that directly influence the process of designing gardens and parks. The process of integrating new technological solutions into already established workflows also requires particular attention and a meticulous approach. For the guaranteed successful implementation of artificial intelligence in the field of landscape architecture, it is essential to ensure full compatibility of new developments with existing systems and strive for the most effective complementary use of them.

Furthermore, the successful implementation of Artificial Intelligence necessitates in-depth specialized knowledge and versatile practical skills. This encompasses not only the initial setup and configuration of AI systems, but also their ongoing management and maintenance, alongside the meticulous analysis of the resulting data to uncover valuable insights. Considering this, landscape architecture professionals must be prepared to proactively acquire these essential competencies. Their acquisition is critically important to effectively utilize the full potential that AI offers within this field. While integrating Artificial Intelligence technologies into landscape architecture involves a degree of effort and investment, it undoubtedly paves the way for realizing substantial advantages. Notably, it will

enable the creation of more sustainable, ecological, and effective solutions for shaping natural environments that are not only functional but also harmoniously integrated into the surrounding context.

Artificial Intelligence is capable of becoming a powerful tool for addressing complex ecological challenges, prominently including the rational management of water resources, the conservation of biodiversity, and the noticeable improvement of atmospheric air quality. Thanks to its ability to process and analyze large datasets, Artificial Intelligence can assess ecosystem needs with remarkable speed and high accuracy. Based on this analysis, it offers optimal solutions for selecting locations for planting vegetation, effective irrigation management, and other crucial aspects of landscape design. As a result of this approach, multifunctional and ecologically resilient green spaces are created, which not only noticeably improve people's quality of life but also contribute to increasing the stability and resilience of ecological systems. Thus, the application of Artificial Intelligence in landscape design can become a key factor in achieving a harmonious balance and sustainable interaction between natural and artificially created environments. Additionally, the implementation of Artificial Intelligence also plays a significant role in reducing overall energy consumption and decreasing harmful emissions into the atmosphere. For example, intelligent automated irrigation systems can effectively optimize water usage, virtually eliminate water waste, and ensure optimal conditions for plant growth and development. Artificial Intelligence is also capable of intelligently managing lighting in parks and gardens, which significantly helps reduce unnecessary electricity consumption. The combination of these factors contributes to the creation of an ecological and sustainable infrastructure that actively helps improve the state of our environment and preserve valuable natural resources for future generations.

### **Smart Cities.**

Also, modern technologies can be used to implement “smart” lighting in cities. LED lamps with a control system allow you to automatically adjust the brightness of the lighting depending on weather conditions or traffic intensity. This not only saves electricity, but also improves safety on the streets, especially at night.

Consequently, the implementation of modern technologies is capable of significantly facilitating the everyday lives of urban residents and making a substantial contribution to achieving sustainable urban development. The continuously growing interest in the concept of “smart” cities clearly indicates that further innovative work in this direction is exceptionally important and forward-looking. After all, the comprehensive utilization of advanced technological solutions is capable not only of simplifying the routine aspects of city life but also of qualitatively improving the urban environment as a whole, contributing to its greening and the optimization of resource utilization. Another defining aspect of a “smart” city, undoubtedly, is the enhancement of the overall quality of life for its inhabitants. An example of this is the organization of high-quality lighting in public spaces, which not only guarantees a proper level of safety and increases the sense of comfort among the urban community but also actively stimulates social interaction between people and promotes their more active lifestyles, especially during evening hours.

The realization of these ambitious goals becomes fully achievable through the active application of advanced sensor technologies. These technologies enable the continuous collection of diverse data, including indicators of weather conditions, traffic flow intensity, levels of atmospheric air pollution, and a whole range of other important parameters that directly affect the quality of life of urban residents. The information obtained from these numerous sources can be effectively utilized for the comprehensive optimization of the operations of various municipal services and for a significant increase in the efficiency of urban planning processes at all levels. Intelligent and well-considered management of key resources, such as energy and water, also plays a crucial role in ensuring not only the economic efficiency of the urban economy but also the long-term ecological sustainability of the entire urban environment. Thus, the “smart” city concept not only significantly contributes to improving the overall quality of life of the urban population but also simultaneously

creates a solid and favorable foundation for further economic development and a tangible increase in the city's competitiveness in the modern digital world.

A critically important aspect within the concept of a smart city is ensuring a reliable level of security and effective data protection. The active collection and comprehensive processing of significant volumes of diverse information, which is an integral part of the functioning of a "smart" city, can potentially become a serious source of various cybernetic risks and threats. This becomes a reality in cases where appropriate and timely cybersecurity measures, capable of effectively preventing such risks, are not implemented. Considering this, developers of technological solutions for smart cities must treat this issue with particular attention. Their primary task should be to guarantee the reliable protection of both the personal data of city residents and the confidential information belonging to the municipality and urban services, from unauthorized access and potential cyberattacks.

Furthermore, in the process of building a "smart" city, it is critically important to steadfastly remember the principles of social justice and inclusivity. During the active implementation of the latest technological solutions, it is paramount to primarily consider the needs of absolutely all population groups, without any exceptions or preferences for individual social groups or specific geographical areas of the city. This approach will effectively help prevent the further deepening of social inequality and potential stratification within the urban community, ensuring equal access to the benefits of civilization for every resident. Thus, the widespread introduction of "smart" technologies in the urban environment opens up a multitude of significant advantages and opportunities, but at the same time inevitably requires a comprehensive and balanced solution to a whole range of complex challenges and potential problems. Ensuring efficient management of urban resources, comprehensive preservation of the environment, guaranteeing a high level of safety for all citizens, and unwavering adherence to the principles of social justice are just some of the key aspects that should be given close attention and primary focus when developing and implementing the "smart" city concept.

### **Modern Technologies and AI Software Applications in The Design of Garden and Park Facilities**

Artificial intelligence (AI) is rapidly changing the paradigm in the world of landscape architecture and garden design, opening up fundamentally new horizons for the design and visualization of diverse garden and park facilities. AI effectively contributes to the realization of modern trends in this field through the utilization of intelligent algorithms that are capable of processing colossal volumes of data and offering the most optimal solutions for each individual project, considering its unique features and requirements. This innovative technology demonstrates an impressive ability to significantly reduce water consumption – by up to 30% – and noticeably increase biodiversity – by up to 20% – within garden and park spaces. Modern landscape design is undergoing an era of profound transformation, made possible by powerful Artificial Intelligence tools. Let's consider in more detail the key AI-powered technologies and their practical application in the process of creating unique and functional garden and park complexes.

Leading AI platforms for design:

#### *Midjourney*

- Creating photorealistic visualizations of garden spaces.
- Generation of various landscape design options.
- The opportunity to experiment with different styles and compositions.
- Quick visualization of ideas for presentation to clients.

#### *DALL-E*

- Transforming text descriptions into visual concepts.
- Generation of unique garden design elements.
- Creating variations of existing design solutions.
- Adapting the design to different seasons and weather conditions.

Generative design in landscape architecture. Generative design uses AI algorithms to generate optimal solutions based on given parameters:

- Analysis of the topography and natural conditions of the site.
- Calculation of optimal plant placement.
- Design of irrigation and drainage systems.
- Creating ecologically balanced compositions.

Generative design tools:

- *ArcGIS GeoPlanner*- spatial data analysis.
- *CityEngine*- 3D landscape modeling.
- *UrbanSim*- simulation of territorial development.
- *ARIES*- mapping of ecosystem services.

Innovations in concept creation. AI is changing traditional approaches to landscape design:

Process automation:

- Quick analysis of soil conditions.
- Selection of plants according to given parameters.
- Optimization of irrigation systems.
- Plant growth prediction.

Design personalization:

- Taking into account the customer's individual wishes.
- Adaptation of projects to local climatic conditions.
- Creating unique landscape solutions.
- Optimizing garden care.

Thorough analysis of historical weather conditions, mandatory consideration of local flora and fauna peculiarities, as well as a comprehensive assessment of potential environmental impact - these are extremely important aspects that need to be taken into account when designing new garden and park facilities. Artificial intelligence is radically transforming the garden design process, opening up a whole range of significant advantages and new opportunities for landscape architects and gardeners.

Personalization and design optimization:

- Analysis of individual user needs.
- Taking into account the characteristics of the site and microclimate.
- Creating unique design solutions for each project.
- Adaptation of projects to budget constraints.

Effective resource management:

- Reducing water consumption by 30% thanks to smart irrigation systems.
- Optimizing plant placement to maximize use of natural light.
- Minimizing garden maintenance costs.
- Reducing pesticide use by 30% through accurate plant health monitoring.

Supporting biodiversity:

- Recommendations for local plant species.
- Creating balanced ecosystems.
- Selection of plant combinations to attract beneficial insects.
- 20% increase in biodiversity compared to the traditional approach.

Improving aesthetic appeal:

- Generation of harmonious color schemes.
- Taking into account seasonal changes in design.
- Creating visually appealing compositions.
- Balance between functionality and aesthetics.

Intelligent monitoring:

- Automatic detection of plant diseases.
- Forecasting care needs.
- Optimization of the maintenance schedule.
- Warning of potential problems.

The use of AI allows you to create "smart gardens" that not only meet aesthetic requirements, but also contribute to the conservation of natural resources. Artificial intelligence systems analyze data on soil composition, lighting, climatic conditions and automatically adjust garden care parameters.

AI technologies provide accurate prediction of plant growth and their interactions, which allows for the creation of long-term sustainable landscape solutions. The integration of AI into garden design contributes to the formation of an environmentally responsible approach to landscaping and landscaping.

**Challenges and Limitations of Utilizing Artificial Intelligence in Garden Design.** The integration of Artificial Intelligence technologies into the realm of garden design inevitably gives rise to a series of significant challenges and potential limitations, which necessitate close attention, thorough examination, and effective resolution:

Technical limitations:

- The difficulty of adapting AI to unique local conditions.
- Insufficient accuracy in recognizing complex natural ecosystems.
- Limited database on regional plant characteristics.

Creative aspects:

- AI can generate standardized solutions, losing the individuality of projects.
- The risk of diminishing the role of human intuition and artistic vision.
- The difficulty of conveying cultural context and historical value.

Ethical issues:

- Protection of users' personal data.
- Copyright issues on generated design.
- Risks of algorithmic bias in decision-making.

The issue of human autonomy in the design process is becoming increasingly relevant. Designers of landscape objects face a dilemma: how to maintain a balance between the technological capabilities of AI and their own creativity.

Practical implementation challenges:

- High cost of developing and implementing AI systems.
- The need for constant database updates.
- The need for special training for staff.

There is a very real risk of over-reliance on Artificial Intelligence technologies, which, in the long run, could lead to a gradual loss of valuable traditional landscape design skills that have been developed over centuries. Leading industry professionals consistently emphasize the paramount importance of preserving the "human factor" in the creative process of landscape design. They stress that, despite the impressive capabilities of AI, it is precisely human intuition, artistic vision, and a deep understanding of aesthetic principles that remain irreplaceable for creating truly harmonious and emotionally rich landscape spaces that reflect the individuality of each project and the needs of the client.

Technological limitations:

- The difficulty of taking into account microclimatic features.
- Limited ability to predict long-term plant development.
- The inability to fully take into account the customer's aesthetic preferences.

AI can be a powerful tool, but it is not a complete replacement for human expertise and creativity. It is important to understand the limits of AI capabilities and use it as an aid, not as a complete replacement for the professional expertise of landscape architects.



### **The Future Use of AI in Garden Design**

The development of artificial intelligence in garden design opens up new opportunities for creating innovative and environmentally conscious garden and park facilities. AI technologies are changing towards personalized solutions that take into account the individual needs of users and the peculiarities of the local environment.

Key trends of the future:

4. Smart monitoring systems.
  - Integration of sensors to track plant health.
  - Automatic adjustment of growing conditions.
  - Forecasting diseases and pests.
5. Automation of care.
  - Robotic systems for pruning and weeding.
  - Intelligent irrigation systems.
  - AI-controlled drones for monitoring large areas.
6. Biophilic design.
  - Creation of natural ecosystems.
  - Integration of local plant species.
  - Supporting biodiversity.

Sustainable practices of the future. AI will promote the development of environmentally responsible horticulture through:

1. Resource optimization.
  - Reducing water consumption by 40-50%.
  - Minimizing the use of pesticides.
  - Effective use of fertilizers.
2. Adaptation to climate change.
  - Selection of resistant plant species.
  - Creation of microclimatic zones.
  - Forecasting extreme weather conditions.
3. Circular economy.
  - Recycling of organic waste.
  - Use of renewable materials.
  - Closed water use cycles.

Artificial Intelligence technologies are relentlessly and rapidly evolving towards the creation of intelligent “living” gardens that are capable of dynamically adapting to constant changes in the surrounding environment and the individual needs of users. The close integration of advanced machine learning with the Internet of Things (IoT) concept will pave the way for the creation of truly self-sufficient and autonomous garden ecosystems. Such systems will be able to function virtually without constant human intervention, independently maintaining an optimal balance. Further development of cloud technologies and powerful big data processing methods will provide Artificial Intelligence with a unique opportunity to analyze the accumulated experience of the functioning of thousands of diverse gardens around the world. Based on this global data, AI will be able to generate the most effective and verified solutions for each specific case of landscape design, taking into account all its unique parameters and goals. All these achievements, taken together, will inevitably lead to the emergence of a completely new generation of “smart gardens” that will qualitatively change our understanding of the organization of natural space.

The integration of artificial intelligence into landscape architecture creates a powerful symbiosis of traditional design methods and innovative technologies. This synergy opens up new opportunities for creating aesthetically appealing and environmentally sustainable garden and park facilities.

Key aspects of AI's impact on landscape design:

- Optimization of design processes while preserving the designer's unique creative vision.
- Increasing the efficiency of natural resource use.
- Creating personalized solutions taking into account local characteristics.
- Improving biodiversity and environmental sustainability of projects.

Artificial intelligence does not replace human creativity and experience - it enhances them. Professional designers receive a powerful tool to implement their ideas, while preserving the authenticity and cultural heritage of landscape architecture.

The application of Artificial Intelligence in garden design encompasses the provision of individualized recommendations, the optimization of resource utilization, and active support for the principles of sustainable gardening. This includes the development of personalized advice aimed at satisfying the unique needs of each client, the efficient use of valuable resources such as water and energy, as well as the promotion of environmentally responsible methods of garden and park management. This contributes to significant conservation of water resources, which is especially crucial in regions with limited water supply, a noticeable improvement in biodiversity due to the creation of favorable conditions for various species of plants and animals, and a tangible enhancement of the aesthetic appeal of garden spaces, making them more harmonious and pleasing to the eye. By analyzing vast datasets that include information on climatic conditions, soil types, lighting, humidity, and other key factors, Artificial Intelligence is capable of creating highly personalized recommendations regarding the selection of optimal locations for planting vegetation, harmonious color schemes, and appropriate materials for paving and decoration. Taking into account a variety of factors, such as the microclimatic conditions of a specific site, soil type, terrain features, and even the site's orientation relative to the cardinal directions, AI ensures the most efficient use of every patch of space and creates the most appropriate and aesthetically appealing landscape design that corresponds to the conditions of a particular location. In addition to this, Artificial Intelligence has the capability to analyze data on previously implemented projects, obtaining valuable information about their effectiveness and identifying potential shortcomings. A thorough evaluation of the performance of past projects helps professionals avoid repeating typical mistakes, refine their professional skills, and constantly improve the quality of their work, learning from their own and collective experience. The application of Artificial Intelligence in garden design not only contributes to a substantial increase in the overall quality of projects and their functionality but also significantly saves valuable time and effort for professionals. This, in turn, frees them from routine tasks, allowing them to focus on developing unique creative concepts, searching for innovative design solutions, and on more fruitful interaction with clients to better understand their needs and preferences.

Artificial intelligence is fundamentally changing our perception of the conceptualization process in design, actively utilizing generative design. This innovative approach allows for the extremely rapid creation of a wide range of diverse design options, based on given initial parameters and clearly defined criteria. Such technology significantly simplifies the design process at the initial stages and opens up fundamentally new possibilities for creative exploration and experimentation with forms and space. In the future, Artificial Intelligence will even be able to conduct in-depth analysis of various ecological factors and predict potential changes in the landscape with high accuracy, which will undoubtedly contribute to more sustainable and highly effective planning of future garden and park areas, taking into account long-term perspectives. However, in the context of the rapid development of technologies, it is extremely important to constantly remember that unique human creativity and unparalleled aesthetic perception of the world still remain unsurpassed qualities that cannot be fully reproduced artificially. Therefore, despite the fact that the automation of many routine processes can greatly facilitate the work of a landscape designer, to achieve truly outstanding results and create masterpieces of landscape art, it is worth persistently striving for a harmonious combination of advanced digital tools with deep human professionalism, experience, and intuition. In the long run, the use of Artificial Intelligence for analyzing environmental factors and predicting

landscape changes will enable the creation of even more sustainable and effective plans for garden areas. However, a key aspect, as before, remains unsurpassed human creativity and unique aesthetic vision. Thus, although automation greatly simplifies the tasks of landscape designers, achieving the best results requires a harmonious balance between the capabilities of digital technologies and irreplaceable human professionalism.

In the near future, we can with high probability expect the further active development of ecologically conscious and sustainable farming practices, driven by the progress and widespread adoption of Artificial Intelligence technologies. This includes a tangible improvement in existing methods for the rational management of natural resources, a deeper integration of environmental aspects and principles of sustainable development directly into the landscape design process, as well as a steady increase in the role of automated systems and intelligent automation in modern landscape design. The implementation of Artificial Intelligence in garden design practice is capable of providing a significant simplification of routine stages of the design process and, importantly, opening up opportunities for the generation of completely new, sometimes unpredictable, but always interesting and fresh design ideas. However, in the pursuit of technological progress, it is extremely important to constantly remember the need to find a reasonable balance between the effective use of advanced technologies and the careful preservation of unique human creative individuality and professional autonomy. In the long-term perspective, we can quite reasonably expect an even more intensive development of various sustainable practices, as well as an ever-increasing impact of Artificial Intelligence on the field of garden and park design. This, undoubtedly, will actively contribute to the creation of more environmentally friendly, harmonious, and aesthetically expressive garden spaces that will bring satisfaction to many generations. The gradual increase in the significance of Artificial Intelligence in garden design may also initiate qualitative changes in our perception of nature and ways of interacting with it, opening up new horizons for the harmonious coexistence of technology and natural ecosystems. Active use of automated irrigation and intelligent climate control systems is capable of effectively helping to maintain plant health and ensure optimal, scientifically sound use of valuable water resources, preventing their inefficient consumption. We can also quite reasonably expect the emergence of fundamentally new technological solutions that will allow for the creation of truly "smart" gardens of the future, where diverse plants will actively interact both with each other and directly with people and the surrounding environment, forming dynamic and interactive ecosystems. At the same time, it is extremely important to closely monitor that this rapid technological progress in no way disrupts the existing natural ecological balance and does not suppress the unique natural beauty and harmony of the surrounding garden spaces. Artificial Intelligence has significant potential to tangibly improve the quality of life for many people by ensuring a more sustainable and economically efficient use of limited natural resources. However, to guarantee the undeniable success of such innovative technologies in the field of garden design, it is necessary to take care in advance to carefully preserve the "human factor" in the creative process and the unique unpredictability of nature itself. It is precisely these factors that give unique individuality, special charm, and natural beauty to our beloved gardens, making them so attractive and valuable to us. Ultimately, finding the optimal balance between the capabilities of advanced technologies and the wisdom of nature itself is a key task for the further successful development of sustainable practices in garden design for the benefit of future generations.

## Conclusions.

Artificial intelligence is currently enacting a veritable revolution in the field of landscape architecture, fundamentally altering traditional approaches and unveiling novel perspectives. Forging unprecedented opportunities for both pioneering design and the streamlined management and upkeep of diverse garden and park amenities. Cutting-edge Artificial Intelligence technologies unlock the subsequent capabilities:

- Generate innovative design solutions.
- Optimize resource usage.
- Increase the environmental sustainability of projects.
- Improve visitor experience.

Integrating AI into landscape design paves the way for creating "smart" green spaces that adapt to user needs and environmental changes.

Promising areas of development include:

- Development of specialized AI tools for landscape architects.
- Improving automated plant care systems.
- Creating personalized recommendations for visitors.
- Implementing predictive analytics for green space management.

Fruitful collaboration between humans and Artificial Intelligence in the field of landscape design establishes a truly unique symbiotic relationship, where advanced technologies act not as a replacement, but as a powerful tool for qualitative enhancement of the creative potential and long-standing professional expertise of specialists. This partnership actively shapes an entirely new era in the evolution of landscape art, where innovative technological solutions are employed to achieve a noble goal – the creation of harmonious, ecologically balanced, and sustainable green spaces of the future that will delight the eye and benefit many generations to come.

The future of the industry lies in the balance between technological capabilities and traditional approaches. The successful integration of AI into landscape design depends on the ability of professionals to adapt new technologies to existing practices, creating harmonious and functional spaces for future generations. The integration of artificial intelligence into landscape architecture can have a significant impact on the quality and sustainability of garden and park facilities. The use of AI helps to optimize design processes, while maintaining the designer's unique creative vision. In addition, artificial intelligence allows you to create personalized solutions that take into account local features and promote biodiversity. The use of AI also helps to efficiently use natural resources, making projects environmentally sustainable. In a practical sense, this means creating attractive and functional spaces that take into account the needs of the present and the future. Thus, artificial intelligence can become an indispensable assistant to landscape architects, contributing to the harmonious development of man and nature. The application of this technology in landscape design is proving to be a powerful tool for achieving a balance between functionality, aesthetics and environmental sustainability of projects. It is important to note that the successful implementation of AI in this industry requires ongoing professional development and attention to the ethical aspects of the use of artificial intelligence. All this can be a key factor in ensuring the quality, efficiency and aesthetic appeal of projects. Therefore, the use of artificial intelligence in landscape design not only speeds up and facilitates the work of the designer, but also helps to create a truly living and balanced space for the future.

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