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Comprehensive Use of Artificial Intelligence in 3D Animation Design

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ABSTRACT

The digital workspace is one of the main tools of design activity in the creative industries. In particular, in multimedia design, the traditional means of performing design tasks, among other possible ones, is determined by specialized digital software for editing multimedia content. Examples include software for editing vector and raster graphics, video editing, and working with digital three-dimensional graphics. It is advisable to form a functionally oriented typology of artificial intelligence models and more applied schemes for integrating generative systems into the design process. The purpose of the study is to develop a comprehensive approach to integrating artificial intelligence into design activity for three-dimensional animation design through the formation of a generalized scheme for applying functionally defined types of artificial intelligence models at the main stages of the production process. The study identifies the main stages of project activities in creating three-dimensional animation, develops a typology of user-friendly artificial intelligence systems in the context of application in design project activities, analyzes the possibilities of applying certain types of artificial intelligence systems at each stage of project activities, and summarizes the results of the study in a structural diagram of the complex integration of artificial intelligence into the design of three-dimensional animation. The study substantiates that the development of algorithmic data processing systems – "artificial intelligence" systems – is a source of replenishment of the tools of the digital work environment, in particular, both in the form of separate user interfaces for controlling the work of artificial intelligence, and in the form of integration of algorithmic systems into traditional software.

KEYWORDS

three-dimensional animation, artificial intelligence, multimedia design, algorithm, project activity, digital workspace.

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Комплексне використання штучного інтелекту у дизайні тривимірної анімації

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АНОТАЦІЯ

Цифрове робоче середовище є одним з основних засобів проєктної діяльності у творчих індустріях. Зокрема, у мультимедійному дизайні традиційними засобами виконання дизайнерських завдань, серед інших можливих, визначається спеціалізоване цифрове програмне забезпечення з редагування мультимедійного контенту. Прикладами можуть бути програмне забезпечення з редагування векторної та растрової графіки, відеомонтажу, роботи з цифровою тривимірною графікою. Доцільним є формування функціонально орієнтованої типології моделей штучного інтелекту та більш прикладних схем інтеграції генеративних систем у дизайн-процес. Метою дослідження є розробка комплексного підходу інтеграції штучного інтелекту у проєктну діяльність з дизайну тривимірної анімації через формування узагальненої схеми застосування визначених за функціональним призначенням типів моделей штучного інтелекту на основних етапах виробничого процесу. У дослідженні визначено основні етапи проєктної діяльності у створенні тривимірної анімації, розроблено типологію користувацьких систем штучного інтелекту у контексті застосування у проєктній діяльності з дизайну, проведено аналіз можливостей застосування визначених типів систем штучного інтелекту на кожному з етапів проєктної діяльності, узагальнено результати дослідження у структурній схемі комплексної інтеграції штучного інтелекту у дизайн тривимірної анімації. У дослідженні обґрунтовано, що розвиток алгоритмічних систем обробки даних – систем «штучного інтелекту» – є джерелом поповнення інструментарію цифрового робочого середовища, зокрема як у вигляді окремих користувацьких інтерфейсів керування роботою штучного інтелекту, так і у вигляді інтеграції алгоритмічних систем у традиційне програмне забезпечення.

КЛЮЧОВІ СЛОВА

тривимірна анімація, штучний інтелект, мультимедійний дизайн, алгоритм, проєктна діяльність, цифрове робоче середовище.

1. Introduction

Part of the broad concept of multimedia design is the direction of design of three-dimensional animation – an animated work that was created mainly through working with digital three-dimensional objects in the appropriate software environment. As a project activity, the design of three-dimensional animation is complex and consists of certain sequential project stages with different types of intermediate multimedia content.

The development of artificial intelligence systems encompasses the generation of a wide range of such content and has the potential to make significant changes in project activities. However, the application of artificial intelligence systems in three-dimensional animation design is mostly fragmentary. In the context of effective utilization of the potential of artificial intelligence, it is necessary to systematize and form an integrated approach to integrating such systems into project activities in accordance with design activities.

2. Literature Review

In accordance with the topic of the complex use of artificial intelligence in project activities for the design of three-dimensional animation, conceptually fundamental in modern scientific literature are works that highlight the specifics of dividing project activities into stages in the context of existing artificial intelligence systems for generating multimedia content. Scientific works by authors such as Chen et al. and Jinn et al. consider multimedia design products, in particular three-dimensional animation, as a set of multimedia elements, for example: text, images, sound, in the work on which it is theoretically possible to use artificial intelligence models for the generation of appropriate multimedia content [2; 8]. An example of the typology of artificial intelligence models according to the principle of the final result of generation is given. The logic of the application of specific artificial intelligence models is determined by instrumental and structurally integrated into the production process according to the scheme of distribution of project activities, according to the main stages of three-dimensional animation design, which mainly include conceptual design, three-dimensional modeling, animation of three-dimensional objects, and post-production. approach in the work of Kardianawati et al. The author's project plan for the integration of artificial intelligence into project activities for the design of animated video material in general is tested, the possibility of effective application of artificial intelligence is demonstrated, and the problems of control over generation processes are formulated [9].

In the work of Wahyudin et al., using the example of a single project, the potential for integrating artificial intelligence at different design stages of three-dimensional animation design is empirically determined. In the context of the use of artificial intelligence, such project stages as plot creation, script writing, visualization of animation scenes, generation of voice accompaniment, speech synchronization, generation of musical accompaniment, and post-production were indicated [15].

In national scientific sources, the topic of the complex use of artificial intelligence in the design of three-dimensional animation is covered mainly in an overview. In the work of Shaura, an analytical review of the impact of the emergence of generative systems on multimedia design project activities in general is carried out [14]. Bobryshev highlights the use of artificial intelligence systems in the process of creating three-dimensional models within the Blender software environment [1]. These national scientific papers note the need to adapt the design activities of designers for the effective use of artificial intelligence tools in design processes.

3. Problem Statement

Relevant in the analysis of current scientific research on the topic are scientific works that formulate the methodological basis for an integrated approach to the integration of artificial intelligence technologies regarding the use of artificial intelligence models of different types of generated content in multimedia design project activities as a whole. The research confirms the possibility of using artificial intelligence in design and directs further research into the specifics of the use of artificial intelligence in the context of the traditional project approach. At the same time, these scientific works are mainly technical in terms of describing artificial intelligence systems; superficial coverage of the theory of the

application of artificial intelligence systems as a user practice of designers; In the context of the integration of artificial intelligence, a superficial analysis of project activities on the design of three-dimensional animation as a separate direction. It is advisable to form a functionally oriented typology of artificial intelligence models and more applied schemes for integrating generative systems into the design process.

The purpose of the study is to develop an integrated approach to integrating artificial intelligence into project activities for the design of three-dimensional animation through the formation of a generalized scheme for the use of types of artificial intelligence models defined by functional purpose at the main stages of the production process. The following research tasks have been formed: to determine the main stages of project activities in the creation of three-dimensional animation, to develop a typology of user artificial intelligence systems in in the context of application in design activities, to analyze the possibilities of using certain types of artificial intelligence systems at each stage of project activities, to summarize the results of the study in the structural diagram of the integrated integration of artificial intelligence into the design of three-dimensional animation.

4. Methods and Materials

The methodological basis of the study is a systematic approach, which allows us to consider the design process of creating three-dimensional animation as a sequence of interrelated design stages. Structural-functional analysis is used to determine the functions of artificial intelligence at each project stage. Typology is carried out to group artificial intelligence models by functional purpose in the context of design project activities. In the construction of a comprehensive scheme for the use of artificial intelligence, the modeling method is actualized.

The structure of project activities for creating three-dimensional animation is determined as the basis for further correlation of artificial intelligence models with the design process. The logic of the production cycle consists of the necessary and gradual stages of creating the final multimedia product of three-dimensional animation.

Conceptual design is a classic first stage in multimedia design activities in general. At this stage, the idea of a design product is created. In the context of three-dimensional animation, at the stage of conceptual design, it is necessary to determine the purpose, plot content and stylistic direction of animation. The specificity of the designer's work lies in the use of text and graphic tools for creative search, fixation, and possible preliminary visualization of the components of the concept.

A further specialized design stage is three-dimensional modeling. Three-dimensional modeling in the context of creating animation is a complex activity consisting of the creation of three-dimensional objects and textures, followed by the spatial and light construction of a three-dimensional scene within which the animation will be carried out.

Within the next stage of animation, the logic of movements is applied to static three-dimensional objects, which is represented by a sequence of fixed positions of objects on each individual frame of the animation. The work of designers at this stage mainly consists of assigning the necessary spatiotemporal positions of objects on a three-dimensional scene.

At the predominantly technical stage of rendering, a sequence of image frames is created from a space-time three-dimensional scene, which makes up the video sequence of three-dimensional animation. The designer's activity at this stage and in the future focuses on working with the visual part of the resulting video sequence.

The final stage in terms of the visual component of animation is post-production, which consists of additional editing of the video sequence in accordance with the defined concept.

It is not part of the visual component, but can be considered as part of the further comprehensive integration of artificial intelligence into project activities, the stage of sound design, which indicates in combination or separately with voice acting and musical accompaniment.

5. Results and Discussion

The sequence of design stages is defined in accordance with traditional approaches to organizing the production process of three-dimensional animation. In the context of the traditional design

approach, conceptual design, three-dimensional modeling, animation of three-dimensional objects, rendering, and post-production are considered as interrelated components of the holistic design process [10]. In the context of integrating artificial intelligence systems into three-dimensional animation design project activities, the traditional approach takes into account the technical content of each stage and the specifics of design activities, which determines the logic of decision-making.

A comprehensive typology of user models of artificial intelligence is used with the distinction of three analytical levels: functional – the type of generated result, front-end – the method of interaction with the model, and process – the stage of project activity at which the model is applied. The basis of the approach to typology is the result of the work of artificial intelligence; the secondary component is the way of user interaction with artificial intelligence models. This approach is based on the relevance in the context of design activity of the generation object and the method of managing the generation process. Typology generalizes the functional logic of the work of types of artificial intelligence models from the quantitative representation of specific generative systems. The following is a typology used in the proposal for the comprehensive integration of artificial intelligence into three-dimensional animation design project activities.

Current research on artificial intelligence demonstrates the classification of generative models mainly by technical structures and the type of operational data. However, in the context of design activities, a functional approach to typology is more appropriate, focusing on the resulting generation result and the way the user interacts with artificial intelligence models [5; 13].

At the functional level, it is LLM (Large Language Models, or text models of artificial intelligence with the functional purpose of generating text content.

At the functional level, AI models for generating static images. This classification does not take into account the way in which it interacts with the model. At the interface level, according to the way of user interaction, image generation models can be represented as TTI (Text-to-Image), which generates images based on text queries, and ITI (Image-to-Image), which involves generation based on the input image.

Artificial intelligence models for the generation of digital three-dimensional objects. At the interface level, according to the way the models interact with the generation of three-dimensional objects, both TT3D (Text-To-3D) models and IT3D (ImageTo3D) models can be represented, within the user interfaces of which generation is carried out based on text queries or static images, respectively.

Artificial intelligence systems for the generation of motion logic in the context of the animation of three-dimensional objects. The functionality of such systems lies in the generation of probable motion logic on the main existing key spatiotemporal parameters of the animated object. The user component of these systems is mainly integrated into broader software environments [4].

A more general type within the topic includes separate or integrated artificial intelligence systems within the wider software environment for optimizing and expanding tools in rendering and post-production processes. Typical post-production tasks can be partially or fully performed during the rendering phase, such as pre-styling through appropriate visual render settings.

According to the author's proposal, sound models of artificial intelligence with the function of generating sound and voice accompaniment are submitted for consideration as a separate type. User interaction with these models is mainly carried out within the framework of a separate software environment through text requests and user interfaces.

In the future, a connection is established between possible design needs at each of the described design stages of three-dimensional animation design and the functional purpose of certain types of artificial intelligence systems. The user component of the above typology is used as a tool for the designer's interaction with generative systems.

The use of artificial intelligence at the conceptual stage mainly actualizes text models and image generation models. Text models can be an additional tool for creative search for ideas, supporting the process of writing a script and planning a project. control. This creates prerequisites for a separate topic of the specifics of coordinating different AI models within the framework of design project activities. Image generation models at the conceptual stage can be a tool for pre-visualization of ideas with greater variability compared to traditional methods. The integration of artificial intelligence at the conceptual design stage is characterized by flexible control of the designer, who determines the degree of automation of the tasks of the conceptual stage and is the subject of critical selection of the generated

content that will be involved in the production process. The use of generative models at the conceptual design stage is consistent with approaches to the development of creative tools, within which generative systems are considered as a means of expanding the variability of concepts and optimizing the designer's creative process [11].

The use of artificial intelligence at the stage of three-dimensional modeling is actualized in accordance with the specifics of the workflow: the use of models for generating three-dimensional objects – TT3D – for the formation of basic geometry and textures; the use of image generation models, in particular at the interface level – TTI and ITI – in working with textures; the use of language models – LLM – and image generation models, in particular TTI as an interface implementation, in the conceptual design of three-dimensional environment, animation scenes as a whole. Limited user control of the direct generation process may be characteristic. However, the specifics of the workflow of three-dimensional modeling and texturing may imply a reduction in the criticality of the conceptually inappropriate quality of the generated content. It is assumed that the generative process is capable of creating content, which, if it meets technical requirements, can be used for further use in the production process while maintaining efficiency relative to traditional methods. Current research determines the possibility of this use of artificial intelligence systems to create basic digital geometric shapes, with the subsequent use of the obtained three-dimensional models at the initial stage of the modeling process [12].

At the animation stage, the generative method is more functionally constrained. Methods for generating the movement of three-dimensional objects based on artificial intelligence systems in the tasks of the animation design stage demonstrate the ability to automate the creation of intermediate motion states using a limited set of keyframes [6]. Motion generation can optimize the animation process, in particular in the context of reducing labor intensity and execution time, but it causes problems with the correspondence of the generation results to the concept. User control of the generative process is mainly carried out through the clarification of keyframes. Depending on the concept, the automation of the animation process can be significantly limited or impossible, in particular in cases where the time of traditional execution is correlated with the time of correction of the generative process.

At the rendering stage, the use of artificial intelligence is the optimization of computational processes, which, in the context of the designer's activities, reduces the transition time of the animation presentation form from the logic of the software environment to the video sequence, in the work on which greater creative control is actualized at the post-production stage. The development of generative rendering approaches allows for a significant increase in the efficiency of computing processes and the quality of visual results through the use of artificial intelligence [3]. In project activities, it is possible to use artificial intelligence in order to optimize, for example, visual noise, increase resolution, and for the purpose of additional visual stylization. In addition to generative systems within a wider software environment with video editing, models may be relevant at the post-production stage, artificial intelligence for image generation, which mainly acts at the heart of VTV (Video-To-Video) artificial intelligence systems for video generation.

The conceptual introduction of sound design into the design activities of designers is due to the user capabilities provided by sound and voice models of artificial intelligence, such as the generation of audio works and voice accompaniment. Current research on the topic of music generation confirms the possibility of using generative systems in the creation of this audio content [7]. In conditions where the generation results correspond to the concept, these models can be a multimedia design tool that comprehensively optimizes the production process.

Generalization of the defined functionality of types and the correlation of artificial intelligence systems with the stages of project activities for the design of three-dimensional animation allows us to form a structural model of the complex application of artificial intelligence, reflecting the sequence of use and logic of integrating artificial intelligence tools into the design process.

The results of the analysis are summarized in the form of a compliance matrix reflecting the relationship between the stages of project activities, types and functionality of artificial intelligence models (Figure 1).

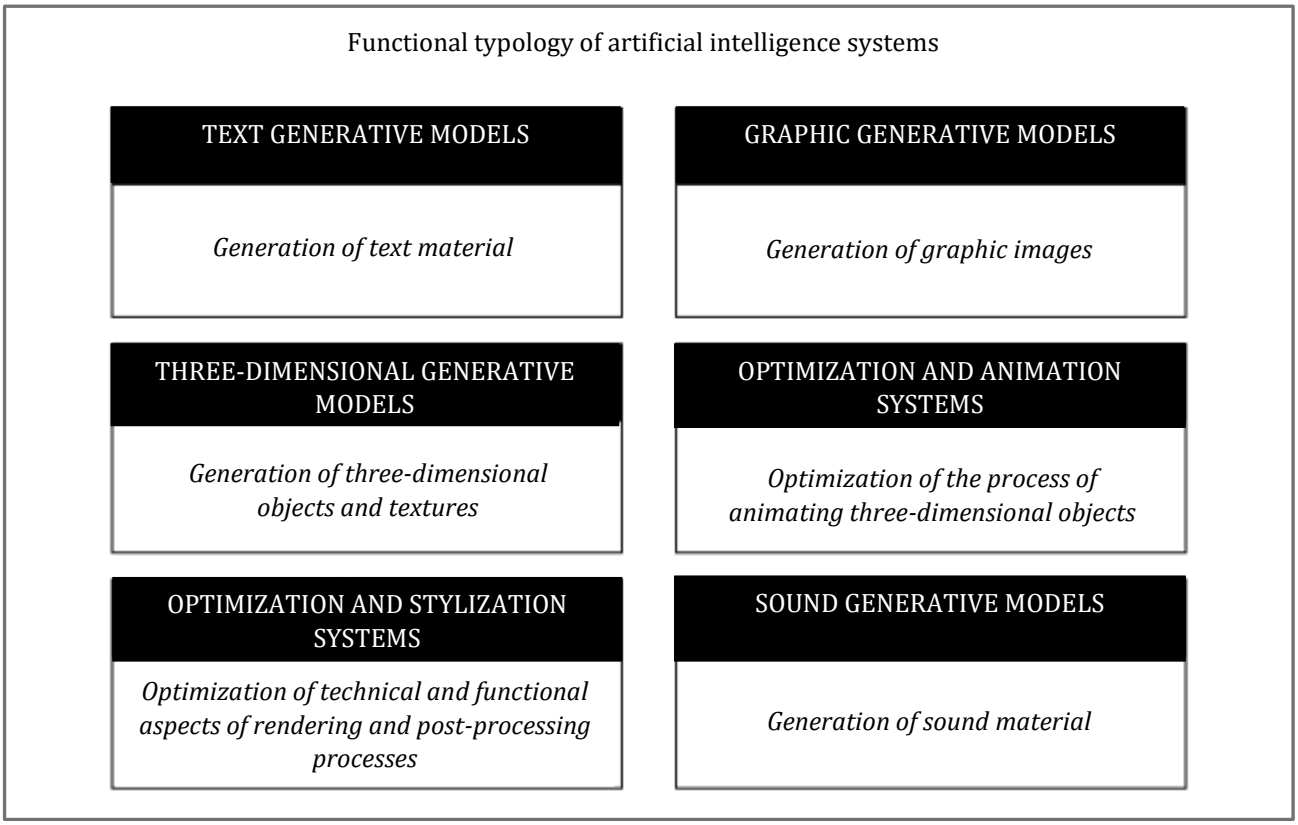

Figure 1. Functional typology of artificial intelligence systems

Source: Summarized by the authors.

Further generalization of the results obtained led to the development of a structural scheme for the integrated use of artificial intelligence in the design of three-dimensional animation, demonstrating the logic of integrating different types of models within a single production process (Figure 2).

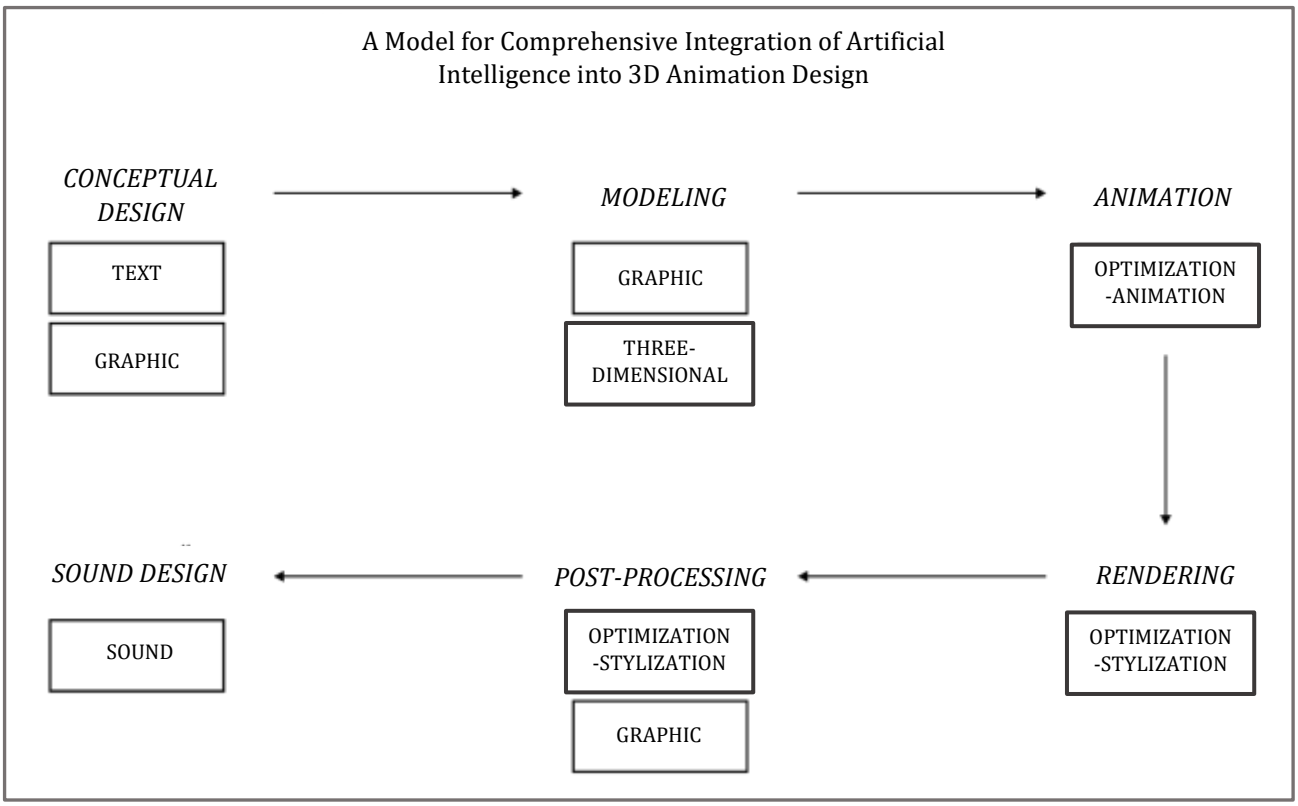

Figure 2. Model of Comprehensive Integration of Artificial Intelligence into Three-Dimensional Animation Design

Source: Developed by the authors.

As a result of the study, a concept of an integrated approach to integrating artificial intelligence into project activities for the design of three-dimensional animation was developed. The complexity of integration is achieved through the use of different types of artificial intelligence models within individual design stages of the design process. The typology of artificial intelligence models is proposed on the basis of the types of content obtained as a result of the generation, functional purpose and interface of use in the production process of three-dimensional animation. In accordance with the specifics of professional activity in the design of three-dimensional animation, the defined types of artificial intelligence models are text generative models, graphic generative models, three-dimensional generative models, optimization animation systems, optimization stylization systems, and sound generative models.

6. Conclusions

The developed integrated approach to the integration of artificial intelligence theoretically makes the instrumental application of artificial intelligence possible. The approach is to keep designers in user control of generative processes within a holistic three-dimensional animation project. Control is achieved by identifying potential localized cases of artificial intelligence applications within individual project components.

Another practical significance of the study is the possibility of using the proposed typology of artificial intelligence and the structural scheme of integration as a methodological basis for further research on the topic of integration of artificial intelligence into design practice in three-dimensional animation: practical application of artificial intelligence at each project stage, identification of possible changes in the traditional design approach in the context of the use of generative systems, analysis of the specifics of user control needs in within the framework of generative approaches.

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