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The Use of Computer Graphics in Interactive Media Design, a Research

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Abstract. In order to better meet user needs, user-oriented interactive design introduces computer graphics technology to generate, process, and transmit graphical information more effectively, thereby enhancing the practicality, simplicity, convenience, and enjoyment of interactive media. This paper aims to discuss the application of computer graphics in interactive media design. In order to analyze and compare the use of different computer graphics (CG) technologies in different scenarios, this paper classifies the interactive media into three categories according to the different focuses of the purposes, namely distributed interaction media, commercial interaction media and informational interaction media, and discusses the application of computer graphics in interactive media design with specific examples. This paper analyzes and compares the use of different CG technologies in interactive media according to their different purposes, namely distributed interaction media, commercial interaction media and informational interaction media. The paper concludes with a summary of the current applications of computer graphics in interactive media design, and an outlook on the future use of CG technology in interactive media design.

Keywords: Computer graphics; interaction design; interactive media.

1. Introduction

With the rapid development of Internet technology and the widespread popularization of Internet use in this century, interactive media, including social platforms, online games, video websites, etc., have replaced traditional non-interactive media and become mainstream, and people have begun to use interactive media in a wide range of scenarios such as learning, life, work, entertainment, etc., thus gradually expanding the user's needs. The output forms the interactive media comes from the input the users [1]. Thus, interactive media design is a user demand-oriented design mode, which always puts the user experience in the first place. Against the backdrop of ever-expanding user needs, it is urgent to improve the technology of interactive design.

In interactive media, pictures and videos are the main forms of information bearing. With the rapid development of streaming media, the degree of people's reception of graphic information has further increased, and compared with complex and lengthy text information, people are more inclined to browse simple and clear image information or detailed and clear video information. Therefore, for interactive media design, graphics processing is crucial. Computer graphics uses computers to generate and process graphic information, which can realize the efficient and meaningful delivery of images to users. Its development has had a significant impact on traditional non-interactive media, such as television, movies, animation, etc., and its role in interactive media should not be overlooked due to its great advantages in the field of graphics processing.

The use of computer graphics in traditional media has been well proven, and its use in interactive media design deserves further research. The purpose of this paper is to study the use of computer graphics in the design of interactive media with different usage scenarios, focusing on how the advantages of computer graphics technology can be better adapted to the needs of the users in interactive design, as well as the different usage scenarios of different kinds of computer graphics technology, so as to demonstrate the value of the integration of the two emerging fields of computer graphics and interactive media design. It also explores the impact of the limitations of current computer graphics technology on interactive media design, thus triggering an outlook on the future application of computer graphics technology in interactive media design.

2. Interactive Media Design

2.1. Interaction Media and Interaction Design

Interaction design is the practice of designing interactive digital products, environments, systems, and services [2]. Interactive media is a relatively new area of media development. Unlike traditional non-interactive media such as radio and television, where users passively receive information, interactive media are characterized by a much higher degree of user involvement in the transmission, processing and reception of media information. More broadly, any process in which anyone's input has a two-way effect on the output of a program can be called interactive media, and it encompasses a wide range of fields such as computing, art, industry, and entertainment. The primary concern when designing for interactive media is interaction design.

The main purpose of interaction design is to satisfy the user's preferences and needs, and during the design process, it is necessary to anticipate the environment in which the product will be used, and the user's goals and behaviors, in order to develop a solution that meets the user's actual needs and expectations.

Interaction design consists of five dimensions, including text, visual representation, physical objects or space, time and behavior. All these dimensions are centered on the user experience. Due to the user-oriented nature of interaction design, we can also say that interaction design has a strong intersection with user experience design.

Depending on the usage scenario, interactive media can be categorized into three different categories, i.e., Distributed Interactive Media, Commercial Interactive Media, and Informational Interactive Media.

2.2. Three Different Types of Interactive Media

2.2.1. Distributed interactive media.

Distributed interactive media refers to media that can connect distributed users. Its main feature is to help users break through the physical barriers of geographical distance between each other and interact with each other in real-time information [3]. At the same time, distributed interactive media is also the interactive media that is most closely related to users' daily lives. The social media platforms that people use daily, such as Twitter, Facebook, Instagram, etc., online cell phone or computer games, online meeting work platforms, and even the emerging meta-universe in recent years, as long as the media that realize real-time information interaction of distant users can be classified as distributed interactive media. Distributed interactive media helps users realize the interconnection of information in a wide geographic range, providing a more convenient way for people to socialize, entertain, learn, work, etc. and a richer source of information.

2.2.2. Commercial interactive media

Commercial interactive media refers to the use of interactive media in commercial design, with the primary goal of using interactive technology to enhance the competitive value of a product [4]. This type of interactive media has a commercial focus, with strong links to the fields of advertising, tourism, and the arts. Using interactive media to create advertisements is a new model for driving product sales. For example, in the real estate industry, some real estate merchants may use 3D technology to provide customers with three-dimensional real-life drawings, or even 3D walkthroughs, to simulate the housing experience of a property, so that potential buyers can understand the decoration effect without being able to make an on-site visit, thus satisfying the customer's need to know more about the property. For example, VENDER offer Architectural Animation, 3D walkthrough and 3D Flyover services,which will give you a realistic 3D idea of your construction project. See Fig.1..

Commercial interactive media can also include online virtual travel products. Online tours use Virtual Reality (VR), panoramic images, and satellite imagery to help travelers browse museums, zoos, and places of interest online anytime, anywhere, such as Google Arts & Culture's virtual tours and online exhibitions in conjunction with more than 1,200 museums and galleries around the world. Commercial interactive media play an important role in helping the promotion of commercial products, while expanding the experience scenarios of some originally geographically restricted products (e.g., tourist attractions), so that the commercial value is further enhanced [5].

Fig. 1 A 3D walkthrough case made by VRENDER [6]

2.2.3. Informational interactive media

Information interactive media is the use of interactive media for the presentation of information, which can be regarded as a kind of information visualization with interactive nature. The most mature application of interactive media is in the field of Geographic Information System (GIS), which is similar to virtual tours in that it uses panoramic images, VR and other CG technologies to process and present data and information [7].GIS can integrate different types of geographic data on a single map, helping people to more intuitively analyze and understand the correlation between different geographic data. With the development of VR technology and 3D image reconstruction technology in recent years, people can also use live maps to make travel navigation more intuitive and convenient. For example, the following interactive 3D web application was built using the ArcGIS API for JavaScript, see Fig2.

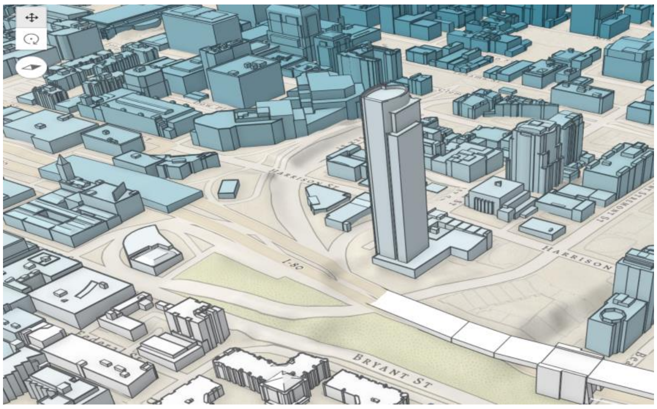

Fig. 2 The interactive 3D web [8]

3. The Use of CG in Designing Three Different Types of Interactive Media

3.1. CG in 3D Game Design for Distributed Interactive Media

3.1.1. The Use of Rasterization in 3D Games

CG technology is widely used in 3D games, which are often modeled with realistic characters, scenes, and environments to enhance the sense of immersion and realism and make the game experience more immersive. CGI production for 3D games has many similarities with non-interactive entertainment, and the most important thing that needs to be paid attention to is the production of special effects in comparison with non-interactive media. Because of the real-time and fast characteristics of the interaction, the game needs to focus on the running speed when rendering and special effects production.

Rasterization and ray tracing are both rendering techniques in CG. Rasterization plays a very important role in rendering 3D graphics to a 2D display. Ray tracing is often used for special effects rendering when working with non-interactive media, while rasterization is often used in games as an alternative to ray tracing. Ray tracing requires high processing and computational power to render complex scenes, especially at high resolutions, and runs slowly on hardware devices often used in 3D games (e.g., home computers, game consoles, and even cell phones). Therefore, the use of rasterization can be a more effective alternative. The process of rasterizing a three-dimensional model onto a two-dimensional plane for display on a computer screen ("screen space") is usually accomplished by fixed-function (non-programmable) hardware in a graphics pipeline, and such dedicated systems can be more efficient [9].

Rasterization works by converting a 3D scene into a 2D graphic before feeding it to the hardware for manipulation and processing. In general, a three-dimensional scene can be divided into a large number of triangular slices. The triangular slices are then transferred into the hardware and eventually presented in the form of 2D images, but give the visual experience that the objects are three-dimensional. We can simply think of every character, object, and scene in a game as being made up of many small triangular slices. In order to improve the performance of the rendering, there are usually also technical means to place the rendered invisible parts or objects that are obscured.

3.1.2. The Use of PBR in 3D Games

Physics-based rendering (PBR) technique refers to the rendering of images in a simulation of real-world lighting and surface optics [10]. A PBR workflow plays a huge part in modern graphics specifically in gaming [11]. It plays an important role in enhancing the realism of game rendering and is well adapted to game engine renderers. PBR can be implemented in real-time applications through shaders.

PBR follows a number of basic physical principles to enhance realism in rendering. The most critical of these is the principle of conservation of energy, which means that the amount of light reflected from an object's surface cannot exceed the total amount of light it receives. Another important principle is the Fresnel effect. The Fresnel effect describes the principle of reflection and refraction adhered to by light traveling through two media with different refractive indices. Adherence to the Fresnel effect helps to ensure that the changes in material reflectance when viewed from different angles in game production correspond to the physical world, which helps to improve the realism and visual richness of the rendered scene. In addition to these two principles, PBR also follows optical principles such as albedo and reflection. In order to characterize and convey complex surfaces, PBR often employs a normal distribution function for normal mapping to select distribution locations, which creates visually rich and accurate rendering results in games.

For example, in the game Uncharted 4: A Thief's End, a lot of superb PBR technology is used, with a high degree of reproduction in the reflection of water, light effects of splashing water, light propagation and reflection, shadows of objects, human skin, various woods, rocks, etc., see Fig.3.a. In Horizon 2:Forbidden West, a lot of PBR technology is also used to render the underwater scenes, including the propagation of light in the water and the reflection of light from bubbles, etc. quite real, bringing players a truly immersive experience, see Fig3.b..

a Uncharted 4: A Thief's End b Horizon 2: Forbidden West

Fig. 3 Examples of 3D games using PBR [10]

3.2. The use of CG in Commercial Interactive Media Design

In recent years, CG technology has exploded in importance and has become key to the development of VR [12]. Computer graphics technology allows for the creation of the various visual elements required for VR virtual environments, including 3D objects, environment modeling, surface texture drawing, and realistic graphics rendering. Computer graphics algorithms are also critical for rendering realistic visuals inVR applications. Using techniques such as ray tracing, shading and lighting simulation can help VR create immersive and realistic environments for users. Meanwhile, computer graphics can be used to design and implement user interfaces and interactive elements inVR environments. Such as menus, buttons, hand controls and other input devices that allow users to interact with the virtual world.

Commercial interactive media, such as the 3D walkthrough and virtual tour mentioned in the previous section, all rely on the support of VR technology. Putting VR technology into the use of goods is also a popular trend in the current market. 3D walkthrough utilizes VR technology, which allows customers to wear VR headset equipment to experience the house type and decoration. Similarly, virtual tour is also combined with VR technology, which allows tourists to wear VR reality devices to feel the scenery in front of their eyes without leaving home.

The workflow for creating a 3D walkthrough or a virtual tour is more or less the same.The first step is to analyze the project in general, such as elevations and floor plans of the space to be created, lighting schemes, object layouts, ambience and style references, envisioning indoor or outdoor environments, and so on. Then the production of sketches, this stage of the rendering of all 3D models and texture mapping are still relatively rough, the picture is mostly a static view or rendered screen shots, the main purpose of this step is to confirm that the style meets the customer's needs, in order to make timely adjustments. After all this is determined to come to the rendering and lighting adjustment stage, in this stage the use of CG technology to touch up the 3D model rendering, the use of a series of techniques such as PBR and other surface texture mapping optimization and improvement, while improving the interactive features, such as navigation menus, etc., to ensure that the interactivity of the product. Finally, the overall project is assembled and debugged with the VR engine to get a complete VR interactive media product. A schematic of the workflow is shown in Fig.4.

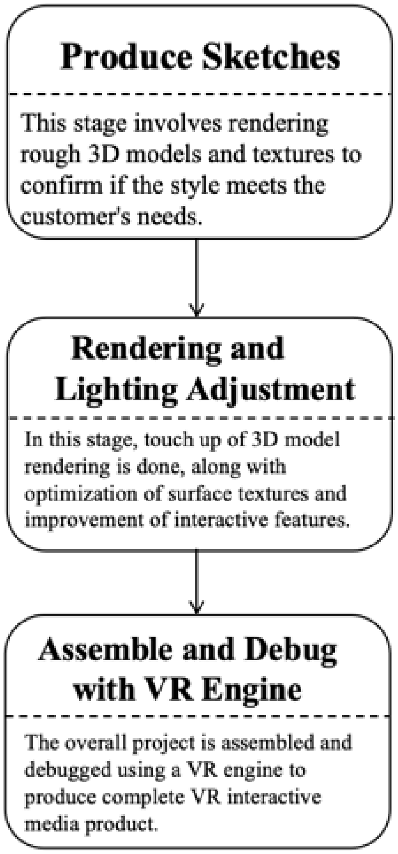

Fig. 4 The Workflow of Creating a 3D Walkthrough with CG (Photo/Picture credit :Original)

3.3. The use of CG in Informational Interactive Media Design

The use of CG technology to realize the construction of 3D GIS is an emerging application of CG technology in information interactive media. As early as 1995, D. Koller et al. proposed a methodology for combining visualization and interactive analysis techniques with VR technology to build virtual real-time 3D GIS [13]. The construction of 3D GIS can help users understand geographic information more conveniently and intuitively when using geographic information systems such as maps. As geographic information detection technology improves and the number of access users increases, the amount of data to be processed to produce a 3D virtual GIS becomes larger, requiring algorithms to simplify the construction process and reduce the number of transmissions to reduce network latency time costs. Researchers from the National Marine Environment Monitoring Center (NMEMC) of China have proposed a method to build 3D GIS using VR and edge computing technology [14]. To put it simply, this method deploysVR devices at user terminals to construct a 3D world space that can integrate real scenes and virtual objects; at the same time,VR is deployed on edge computing nodes, and the number of devices transmitted at the same time reduces network latency to alleviate the computational pressure on data processing centers and reduce computational costs.

3.4. Comparison

Based on the comparison of the methods used by CG in the above examples of 3 different types of distributed media, the differences between them can be briefly summarized in the following table, see Table. 1. While the focus and iteration of CG techniques used in distributed interactive media, commercial interactive media, and informational interactive media varies due to different requirements, the CG techniques used in each type of interactive media are interoperable and complementary. Regardless of the niche of interactive media, CG technology enhances the quality and interactivity of interactive media content by creating realistic 3D graphics, animations and visual effects.

Table. 1 Differences between the Uses of CG in 3 Different Types of Interactive Media

Differences Between the Use of CG in 3 Different Types of Interactive Media			
	Distributed Interactive Media	Commercial Interactive Media	Informational Interactive Media
Design Focus	Perform fast real-time rendering in pursuit of extremely realistic modeling effects, advanced art effects	Modify the modeling according to the user's needs in a timely manner to present the modeling effect that the user needs.	Need to process large amounts of data while reducing the speed of information transfer to reduce network latency
CG Technology	Rasterization, Real-time Light Tracing, PBR, etc.	Workflow for user feedback participation	Edge data detection, etc.

4. The Advantages and Limitations of Using CG in Interactive Media Design

4.1. Advantages

CG technology brings many advantages to interactive media design. First of all, CG technology allows for the creation of realistic visual experiences, from 3D modeling to the texture of object surfaces, as well as lighting and special effects design, thus providing a more immersive experience for the user and enhancing the sense of participation in the interactive process. Secondly, when designing in art-related fields, CG tools provide interaction designers with a wider creative space, enriching the visual style of the work, and narrative techniques, making the interaction process much more interesting. CG technology can also integrate interactive elements to improve the interactivity of interactive media. For example, responsive user interfaces, live map navigation, etc. can help users become more actively involved in media interactions and improve the interactive experience. The use of workflow-style CG production can also help interactive media design to respond to user needs in a timely manner, to make appropriate adjustments to the iteration, in order to improve user orientation based on the enhancement of the efficiency of product development, so as to ensure the quality of the same time to reduce the time cost. CG also helps to improve the cross-platform compatibility of interactive media. Interactive media content based on CG technology can be deployed and accessed on different platforms and device terminals, including personal computers, mobile devices, game consoles, and even head-mounted VR devices, thus meeting the needs of users in more scenarios.

4.2. Limitations

There are also limitations to investing CG technology in interactive media design. The first thing that cannot be ignored is the technical complexity. Designing and developing with CG technology requires a high level of professional skills and tools, so it requires interactive designers to master a considerable level of CG technology and computer science-related knowledge in order to produce high-quality interactive media content. Secondly, CG rendering and various texture processing, computation, etc. require high hardware and computer resources, and some devices with poor hardware performance are often unable to complete such media design. The use of CG technology for interactive media design may significantly increase the production period due to the long time spent on CG rendering, especially for data processing in high resolution. In addition, for users, interactive media products produced using complex CG technology need to occupy a large amount of memory space and require high-performance equipment in order to obtain the best product experience, and there may also be problems of incompatibility with equipment due to the high hardware requirements of the product, which may bring unnecessary inconvenience to the use of the product. The complexity of the design of the interaction may also pose a challenge to some groups (e.g., visually impaired, motor impaired, etc.).

5. Future Research Direction of CG Application in Interactive Media Design

The use of CG technology in interactive media design has a wide range of prospects, and the further enhancement of CG technology will make it more convenient and efficient to use in interactive media design. The future research of CG technology in interactive media design may include the following directions.

5.1. Enhancement of the CG Technology

First, the use of faster and more efficient real-time ray tracing and rendering, including optimization algorithms, hardware acceleration and exploring novel rendering methods. Further research into real-time ray tracing and rendering techniques will lead to more realistic and immersive interactive media experiences. Advancements in interactive global illumination techniques can also open up more possibilities for the use of CG in interactive media design. Interactive global illumination enhances the realism of interactive media environments by simulating complex lighting effects such as indirect lighting, soft shadows, and color bleeding. The focus of its future research will be centered on improving performance and scalability while maintaining visual fidelity.

5.2. Enhancement of the user's sense of use

AI technology has also been advancing at a rapid pace in recent years, and the integration of AI and machine learning techniques into interactive media design using CG technology will enable intelligent content generation, adaptation, and interaction is also a research direction to explore. Incorporating AI technology to accomplish AI-driven program generation, content recommendation systems, interactive storytelling, and adaptive user interfaces can better meet the user-needs-oriented design requirements of interactive media. Research on immersive technologies such as VR, Augmented Reality (AR), and Mixed Reality (MR) in interactive media using CG technology as the basic technology support will drive the development of new interactive media experiences. Immersive displays, tracking technologies, haptic feedback and spatial audio can be implemented using these technologies to create more engaging virtual environments. Future research in interactive media design will also explore multi-user and collaborative interactive media environments that enable real-time interaction and sharing of content between users. This includes the use of CG technologies to implement distributed interactive media systems, collaborative virtual environments, and socialVR experiences for communication, collaboration, and entertainment. Not to be overlooked, we should also focus on using CG technologies to improve the accessibility, inclusiveness, and diversity of interactive media usage scenarios, to ensure that interactive media can facilitate good interactive experiences for a more diverse group of people.

6. Conclusion

This study demonstrates through some prominent examples that CG technology has a very wide range of applications in interactive media design, and plays a crucial role in enhancing the immersion, interactivity, entertainment, convenience, and the use of interactive media, as well as the use of scenarios and use of platforms. Second, this study demonstrates through examples that CG technology is used in the design of three different scenarios of interactive media: distributed interactive media, commercial interactive media, and informational interactive media, and that it is applicable in different domains such as video games, VR experiences, real estate advertisements, and science education transmissions, which underscores the wide-ranging impact that CG has had in shaping the contemporary interactive media landscape. In addition, the research demonstrates the possibilities of CG technology in driving innovation and pushing the boundaries of interactive media design. By utilizing advanced rendering techniques, real-time simulation, and procedural content generation, interaction designers can create rich, dynamic interactive experiences that better meet product interaction needs.

Looking ahead, research on the convergence of CG technologies and interactive media design will explore new frontiers and address emerging challenges. Areas of focus are likely to include advances in real-time rendering, the integration of artificial intelligence and machine learning techniques, the development of immersive storytelling experiences, and the exploration of ethical and responsible design practices. By further expanding the capabilities of CG technology and digging deeper into the value of its use in interactive media, more exciting possibilities for interactive media design in the digital age can be opened up.

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