University of Theatre and Film Arts
Doctoral School

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DESIGNING AND IMPLEMENTING METHODOLOGIES FOR INTERACTIVE WEB 3D ANIMATIONS IN BROADCAST ENVIRONMENTS

DOCTORAL DISSERTATION THESIS

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Table of contents

Introduction 2
Research objectives 3
Structure of the dissertation 4
Personal reasons for topic selection 5
Research results 6
Possible research directions 8

Introduction

The methodology and application possibilities of 3D imaging techniques are undergoing a technological paradigm shift that significantly redefines and expands the traditional 3D authoring toolset and conceptual system. Just as film has become a hybrid genre, the practice of spatial creation has also undergone significant transformation; it has grown into a more-than-three-dimensional, generative, multiplatform, data- and database-based, script-driven, sensory, immersive adaptation process, in which the concept of software-, browser-based art, machine learning, and artificial intelligence-based motion picture production is becoming increasingly meaningful.

Artistic works created by 3D designers can be equally adapted towards broadcast engines, WebGL and WebGPU graphics engines, stereo images, generated illusions of virtual, augmented, and mixed reality. In addition to 3D content embedded in a web-based environment and database-based motion picture interactions, real-time spatial graphical elements can now be described as hybrid and integrated towards any compatible interface. Beyond the above processes, the spread of machine learning, automated processing, and smart systems has a significant impact on the motion picture and creative professions, especially those in which artificial intelligence can be applied.

The simultaneous investigation and application of knowledge from different fields is essential due to the merging of motion picture and development disciplines. Creators must face the challenges of dynamic, platform-independent content creation, and the integration of the artificial intelligence toolkit.

Research objectives

The problem of convergent 3D motion picture creation, the real-time transplantation of media content to different visual platforms, is an increasingly unavoidable issue in modern workflows. In my dissertation, I examine the conditions and applications of redefining 3D authoring toolkits that change in animation processes. In addition to the interactive methods of spatial motion picture design, my analysis focuses on mapping WebGL and WebGPU-based technology, and the syntactic analysis and presentation of digital web 3D script languages.

The objective of my doctoral dissertation is to examine the artistic and technological aspects of real-time, interactively controllable WebGL - WebGPU 3D animations. The goal of my dissertation is to reveal the method of creating a 3D visualization database that can be used in online environments, which allows the adaptation of CGI scenes created in 3D design and animation software to real-time broadcast surfaces.

The focus of my DLA work is the research and creation of data-based automated motion picture processes that allow the objects, animation scenes, and pre-defined parameter systems of traditional three-dimensional design programs to be transmitted with readable data structures and used interactively in 3D web graphics libraries, as well as broadcast frameworks in live broadcast environments.

During my doctoral research, I sought to answer the question of how 3D visualization elements can be transplanted to the latest development tools with artistic methods and technological strategies. I analyzed which optimization methods can be used in the integration process between 3D design software and graphical web 3D libraries in order to make the transplantation of spatial scenes without quality loss possible. The focus of my research was on what methods are available to motion picture professionals that allow the platform-independent adaptation of visualization work to the interactive 3D environment.

Structure of the dissertation

- Introduction: topic selection and structural design of the dissertation
    - Basic concepts: OpenGL, WebGL, WebGPU
    - Research context and the significance of the dissertation
- Paradigm shift in broadcast visualization
    - Criteria for platform independence
    - Challenges of integrating data-driven and generative models
    - Establishment of research hypotheses
- Early history of 3D technology in Hungary
    - Initial works and experimental phases
    - Data-driven filmmaking and CGI television applications
    - International comparison
- Web-based 3D technologies
    - Comparative analysis of WebGL and WebGPU
    - System architecture and broadcast integration
- Full Stack 3D development methodology
    - Front-End and Back-End technologies
    - Client-server architecture
    - Implementation classes and procedures
- Web 3D publication strategies
    - 3D design tool chain
    - Real-time television adaptation
    - Television rendering techniques
- Web 3D future
    - Integration solutions and automated systems
    - Generative techniques and the future of the motion picture professions

Personal reasons for topic selection

In the past 15 years, I have worked in the development environment of real-time 3D broadcast engines, designing automatic graphical template systems, and researching interactive motion picture methods at regional and national television stations. As a senior developer and later Solution Architect, I had the opportunity to participate in the creation of the largest data-driven programs in Hungarian television. My graphic applications appeared in the broadcasts of the most watched domestic programs, and I worked on the development and implementation of the interactive application systems of the Hungarian Television. I have participated in the world's largest broadcast visualization conferences, as well as international workshops on the development of broadcast software and systems. In addition to my work, I have been working as a university lecturer for several years, where I teach 3D visualization tools, 3D technology, and creative motion picture techniques.

That is why I feel it is essential to present this interdisciplinary topic, to consider the simultaneous presentation of the 3D artistic and development disciplines, the application of new digital possibilities, the later publication of my research results, and the representation of my profession.

Research results

The 3D technology presented in the dissertation dates back to a decade, but it cannot be said that these processes revolutionized the practice of spatial motion picture rendering methods today. To date, it has only been possible to implement them with numerous restrictions, exclusively by arguing for and validating the interdisciplinary approach. That is why I do not claim that the available development tools can be seamlessly adapted as part of any motion picture process. I have found that classic film technologies can only be difficult to transfer to the surfaces described as the most modern, numerous conversion difficulties hinder and distort the final result of the intended appearance. The graphic image of the design software cannot yet be transplanted to web-based engines without quality loss.

The extremely dynamically changing programming environment has made it essential to know a wide range of development tools and procedures. Numerous scripting language and syntactic restrictions guarantee the description environment of the visual content that appears in the browser. The expectation systems also significantly influence the publishing workflows of traditional 3D design software. Despite all this, the justification for the unavoidable expansion of web 3D technology was clearly outlined during my research.

Through my DLA master's thesis, I examined the development processes and interactive publication system for creating a web 3D animation database. I revealed the most important methods and analyzed the possible steps and directions of practical implementation. I documented the modules and functions necessary for implementation, and my analyses highlighted the most important development and graphic aspects.

I concluded that the methodology for developing the web 3D development environment, and the analyzed scene integration methods, can justify my research hypothesis that the WebGPU technology contributes to the expansion of the 3D data visualization toolkit of broadcast television and online streaming, making it possible to produce and adapt platform-independent interactive content. I am convinced that by integrating the latest development tools and methodologies presented in the dissertation, scenes from traditional 3D design software can also be effectively adapted to real-time broadcast environments.

From the perspective of interactive animations and video applications, I also examined such historical and modern aspects of motion picture production, the sub-fields of which are constantly approaching internet development techniques. This follows that understanding the knowledge of the methodology for developing the 3D development environment was extremely important for the development of the 3D platform as well. It is becoming increasingly essential for motion picture professionals to learn the operating systems of interactive techniques and the relevant scripting languages.

The discovery of concepts and knowledge that are increasingly moving away from film and video art - surprisingly - brought the latest tools of motion picture production closer and closer to me. Based on this experience, I argue that an interdisciplinary approach to the methods of spatial representation is essential for modern multimedia creators.

Taking everything into account, I believe that I have been able to prove the hypothesis that the integration of WebGL and WebGPU technologies with broadcast data visualization template systems and web-based interactive application elements creates a new, more flexible and more diverse visualization paradigm for television and online streaming channels. I concluded that real-time 3D web visualization is a tool for modern media artists and developers that can be interpreted as a platform-independent, dynamically parametrized, easily adaptable graphical interface in the future.

In addition, 3D WebGPU technology has a significant impact on the development of interactive motion picture content and the transformation of the data visualization possibilities of broadcast television. I came to the conclusion that the statement of my research's concluding thesis can also be justified, which is that the integration of artificial intelligence and machine learning technologies makes it possible to create personalized program elements and platform-independent adaptation of motion picture content.

Possible research directions

In the future, I would like to continue my research on the following areas:

- The use of 3D visualization technologies in new creative and interactive applications.
- The integration of artificial intelligence and machine learning technologies in the context of web 3D visualization technologies.
- The methodology of programmed animation motion picture technology.