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Research paper



The State of Collaborative 3D Content Authoring: A Review

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Abstract

Computer supported cooperative work (CSCW) is one of the key factors to increase company's productivity. Hence, there are numerous researches trying to increase the efficiency of CSCW implementation to achieve a better collaboration between employees. The recent trend of using 3D content demand industry to develop an efficient and effective workflow to create numerous high-quality 3D content. Hence, implementing CSCW in 3D content authoring is a crucial factor in related industry such as game and movie industry. In this paper, we investigate the state of collaborative work in 3D content authoring. We focus our observation in CSCW features currently available 3D content authoring application and game engines. Additionally, we observe recent researches related to developing CSCW application in 3D authoring. The objective of this research is to give a thorough view regarding the state of CSCW in 3D content authoring industry and the possibility of future research and development.

Keywords: *Collaborative Work, Computer Graphic, Multimedia Systems, Computer Supported Cooperative Work*

1. Introduction

In the recent years, the use of 3D content has rise. The demand comes from various sources such as games developers, special effects industry for movies/advertising, simulation application developers, etc. Moreover, the current state of hardware such as GPU (in computers and mobile devices), Virtual Reality device, and Augmented Reality, enables more end users to access 3D content. Hence, the demand of 3-dimensional digital content is rising, and the 3D content industry need to catch up by employing a fast and efficient way to produce high quality 3D content.

To meet this demand, many 3D applications have implemented various methods to aid content development process. Developing a friendly and efficient interface, automating content generation, and providing pre-built content are a few examples of features dedicated to increase the productivity of 3D artists. However, in some cases, the creation process may require collaborative works amongst artists. Large scale object and highly detailed object may require multiple artist to contribute in the creation process. Moreover, the tendency of 3D artists to focus and specialize their skill to specific details may increase the need of collaboration to create a complete content. These facts increase the need of collaboration feature in 3D content development. Hence, it is necessary to observe the current state of 3D authoring application to provide collaboration feature in their application.

While the idea of real-time collaboration on 3D authoring is interesting, there are various technical and conceptual issues that may arise during the development and implementation [1]. One of the main issues in collaborative 3D world is the representation of changes and collaboration in 3D space can be complicated. Users' authority in modifying the content and information exchange regarding the changes can be strenuous. Hence, there are multiple research focus only on developing an interface for real time collaboration on 3D authoring.

Our objective is to perform a study regarding the availability of collaborative feature in currently available 3D applications. Moreover, we also observe various applications that may be used to aid collaborative work. Lastly, we also observer past researches that focus on the development of collaborative 3D content creation tools. The paper is structured as follow; the first section is the introduction that describes the motivation of our research. The second section describes the related works that has been done previously, related to our paper. Our observation result will be explained in the third section followed by conclusion in the last section

2. Related Works

The idea and development of CSCW can be tracked back to the mid 80's [2]–[4] where researchers, motivated by corporate, were struggling to aid cooperative work in office by using computer system. Since then, collaborative systems have become a mandatory feature in modern office. Hence, researchers are encouraged to find a more effective and efficient method to implement CSCW. However, there are numerous fields of study that contribute in the development of CSCW. Some of the research focus on developing a reliable network infrastructure and protocol to maintain communication between users and guarantee data consistency amongst users [5]–[7]. Others focus on the interface of CSCW system such as designing an optimal interface design for co-present collaboration system [8]–[11], developing VR-based environment for collaborative works[12]–[14].

Another important aspect to be considered in developing CSCW system is the social interaction and the organizational behavior that affects the dynamic of collaborated users. One of the most significant social issue in CSCW is to develop a method to raise user's awareness regarding their collaborative work [15]–[17].

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3. CSCW in 3D Authoring

In this section, we will discuss currently available applications that support CSCW as part of its feature. We will go through the application and discuss the capability and limitation of the application. The second part of this section will discuss a research-based application that is part of a related research and discuss the potential of the application.

3.1. 3D Content Authoring Application

In this research, we will focus our the top 3 commercially available application: Autodesk 3DS Max [18], Autodesk Maya [19], and Blender [20]. Additionally, we also would like to observe software related to 3D content authoring such as game engine. Hence, we also add Unity [21] and Unreal Engine [22] on our list.
As one of the pioneers of 3D authoring application, Autodesk applications has become a de-facto standard of CGI industry. Currently, there is no real-time collaboration editing feature developed by Autodesk. However, Autodesk developed A360, a cloud-based system that allows multiple user to share, browse, and navigate through any 3D object that uses Autodesk proprietary file format [23]. The system also allows the users to add notes that can be passed to the creator which can be extremely useful for a large-scale project that requires rapid changes, evaluations, and integrations. Additionally, 3ds Max has Xrefs and Revit [24]. The first one allows a scene to contain object(s) from different project from a different user. The object will be referenced to the original one instead of copied to the scene; hence, any changes made to the object will be applied to the scene.



Fig 1: Proposed Workflow for Collaborating 3D Authoring using A360. Image courtesy of Autodesk [23]

Blender is one of the biggest open source 3D authoring application. It has a huge community with a lot of developers involved in its project. Maintained by a Dutch-based company Blender Foundation, the application has been evolved since the first launch in 1998. However, up until the current version, Blender has no official feature to support real time collaboration. As for the community developed plug-in, there is an open source project called Serve intended to add a real time collaboration feature to Blender [25]. It was based on a protocol developed by Hnidek [26] for communication protocol. This protocol allows 3D data to be shared amongst users. However, we noticed that the development has been stalled since 2016 based on the latest update made by developer. We also noticed that the protocol has been developed and implemented as a 3D Studio Max Plugin [27], but the development has been inactive since 2006.
Other than the applications mentioned before, there are also other applications that was intended to support general collaborative work but can also applied to 3D authoring industry. Revision management system such as Apache Subversion [28], TortoiseSVN [29], Perforce [30], Git [31], and Concurrent Versions System [32] are the most commonly used versioning system in software industry. These systems are able to aid an offline collaboration in 3D authoring by indexing the file based on changes to avoid conflicts between author. Another interesting application to point out is Shotgun, a collaboration tools for entertainment industry that can be integrated to most 3D applications and allows users to share notes and track revisions to content files [33]. The software is intended to aid large-scale project in entertainment industry that involve multiple role such as 2D/3D artist, writer, director, producer, etc. The application works both as a plugin for other content authoring application (3D Studio Max, Maya, Adobe Photoshop) and stand-alone application. The plugin allows multiple user to track, review, and comment on updates made by the creator in real-time. The stand-alone works mainly as a file version management system although it also has other additional collaboration features such as scheduling and resource management.
Other than the previously stated applications, we also observe a few other 3D authoring software which allow real-time collaborative editing. LEDAS Cloud Platform [34]is a client-server modeling application that allows multiple users to perform real-time collaboration in 3D modeling. The application is built as a web-based application, allowing it to be run on all major web browsers. Similarly, Modelo [35] also offer a cloud based 3D authoring web application that allows collaborative work. SolidFace [36] offers a 3D modeling software solution that features a real-time collaboration via internet connection.

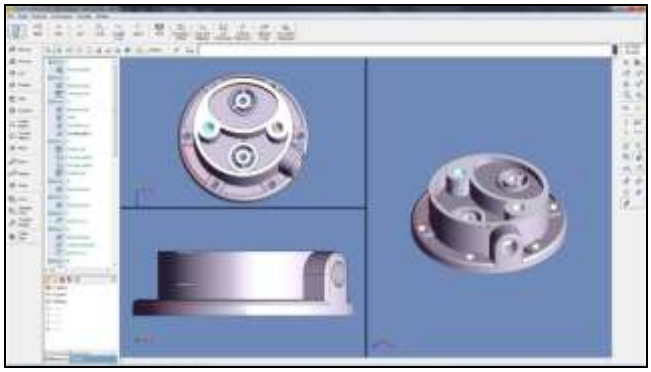

Fig 2.: The Interface of SolidFace. Image courtesy of SolidFace Technology Inc. [36]

3.2. 3D Game Engines

Naturally, collaborative features are essential in game engines since game development involves multiple users with multiple roles such as Programmer, Game Designer, Game Testers, etc. In this paper, we observed two most used game engine: Unity and Unreal Engine. While we also observe currently available third-party plug-ins, our focus is the feature that comes along with the software.
For collaborative project, Unity offers Unity Teams [37]. It provides 4 main features: Collaborate, Cloud Storage, Project History, and Cloud Build. Collaborate acts as a version control where users are able to track changes made by other users thus minimizing the conflict. Cloud Storage allows project to be stored in Unity's cloud storage accessible by internet. This feature allows users access the project remotely. Project History allows users to revert project to previous version. Cloud Build allows the project to be built on a cloud-based system, allowing users to work without concerning computer resource required to build the project. Moreover, multiple users may require multiple build which in result create multiple output version. This feature allows the team to manage and browse multiple build output. These four collaboration support features are included in Unity Teams which comes in free basic version and advanced paid version.
Aside from these built-in features, there are also numerous third-party Unity plug-ins that aimed to support CWCS in Unity. Scene Fusion from Kinematic Soup [38] is one of the most best CSCW plug-in in Unity. It allows multiple users to perform collaborative work on one scene in real time. Additionally, the plug-in also allows users to build and run the scene while other users edit the content, allowing the team to modify and test the scene concurrently. As for version control, there are various third-party plug-in

available on Unity's Asset Store. GitHub for Unity [39], UniMerge [40], and SVN Tools [41] are three of the most popular version control tools available on the market. GitHub for Unity is a free and open source tools that implements GitHub workflow to Unity Projects. SVN Tools allows users to use SVN commands to perform version control, which is preferable to users with experience on using Apache Subversion [28]. UniMerge offers a full visual experience and have the capability to compare scenes and prefabs (instead of only comparing files).



Fig 3: Multiple Users, marked by different use of colours, performing actions to a scene. Image courtesy of KinematicSoup.

Similar to Unity, Unreal Engine has also included collaboration support tools in the application. Initially, the software support Perforce and SVN as built in version control tools [42]. However, there is no software or plug-in currently available that allows real-time collaboration between users to work on the same scene. However, it is important to notice that KinematicSoup is currently working on an Unreal Engine version of Scene Fusion.

3.3. Related Research

Other than the commercially available application mentioned above, there are numerous research that focus on developing CSCW 3D authoring. Imae et al developed ChainVoxel [43], a data structure for their collaborative 3D editing application [44]. The proposed system guarantees a conflict-free data structure for a voxel based 3D modelling. Ha et al. proposed Lets3D, an application that allows collaborative 3D editing [45]. However, the proposed system does not allow multiple users to edit an object. Instead, users can add primitive models to the scene and apply transformation to the object. Nishino et al. proposed an approach to implement real time collaborative 3D modelling [46].

4. Conclusion

There are numerous 3D authoring applications that has already supported CSCW in their system. Most 3D authoring application has already supported file version control. However, based on our investigation, support for real-time collaborative authoring that allows multiple users is limited. Major 3D authoring tools such as Maya and 3D Studio Max has features to support off-line collaboration. However, these applications are lack in real time collaboration. There are also a few 3D modeling software that support real-time collaboration.

The purpose of this research is to give a thorough review in CSCW in 3D authoring tools. This information would be useful for further development on the area. Based on this research, our intention is to perform a research to develop a CSCW 3D authoring tools, specifically a feature to support real time collaboration on a scene or object.

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