Development of a Previsualization Proxy Plug-in Tool

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***Abstract*—Previsualization, also known as previs in the digital content industry, is becoming increasingly important. Previsualization in animation, movies and visual effects (VFX) can enhance ideas and creative story production. Thus, unnecessary expenses can be minimized while output quality can be improved. It is crucial to produce proxy modeling that can implement animation quickly during the previsualization production stage. The process is often ignored because additional procedures are needed, and it takes a relatively long time for an unskilled person to produce proxy modeling. Therefore, it is imperative to develop a proxy plug-in tool to simplify the motion process using an easy method. A new method was developed for creating a bounding box by attaching it to each joint, differentiating it from the existing high-poly to low-poly working process. This unique proxy plug-in development method allows us to proceed with the motion process in fewer steps, with better operation, steady speed performance, and a precise shape to work efficiently in previsualization. Using the proxy plug-in tool to perform the motion may be a solution for creating easy access to previsualization and story production.**

***Keywords*—proxy plug-in, previsualization, proxy modeling, animation**

I. Introduction

Since the 1980s, advanced technology has dramatically stimulated computer animation into a viable commercial industry [1, 2] and has become more subdivided and sophisticated. Therefore, the film and animation industries used 3D previsualization as a primary method to complete the cooperation work [3, 4]. Previsualization became more popular with George Lucas's Star Wars prequel, and it is almost a must in the preparation for many big-budget companies currently [5].

Previsualization is a visual process that can easily display a visual output to efficiently modify the required needs and motions to enhance the animation and film production team's exploration of creative and better ideas [6]. Previsualization is also beneficial in educational systems. In particular, because it is more beneficial to understand a specific idea by visualizing it rather than expressing it in writing, visualization animation technology is becoming more popular in education [7]. However, previsualization requires additional training and is time-consuming, which is a problem needing a solution. Because of the complexity, extra trained personnel, budget, and time needed, many schools and industries avoid the previsualization process [8]. In contrast, creating the final results without a previsualization production process would make it difficult to modify, leaving it as a limiting factor in the story's composition.

The main obstacle in implementing the previsualization step is to create all the 3D objects ready in place in complex 3D tools such as Blender, Maya, Unity and Unreal [9]. 3D tools such as Maya are not designed for the previsualization process but instead create high-quality 3D modeling and animation [10]. In contrast, the proxy geometry has the advantage of fast performance in the viewport [11]. Therefore, the previsualization step requires proxy modeling, which is crucial because proxy modeling replaces high-resolution geometry in the previsualization stage.

Additionally, proxy modeling requires rigorous skills to link with controllers to enable character movements during previsualization. If the proxy modeling process takes time to generate and is inefficient to work with owing to lack of rigging knowledge, the previsualization process is an impediment, rather than a benefit. With these problems, students usually avoid the previsualization process in an educational institution. Furthermore, many standard automated rigging tools exist, but it is not easy to download a previsualization tool linked to the rigging system.

Therefore, a study developing a proxy plug-in tool with an easy process is necessary for many education and industries to process the previsualization pipeline easily. The goal of this study is to create a proxy plug-in tool to efficiently solve complicated requirements, access the previsualization process and enhance the 3D content working outcome.

Therefore, a new low-resolution bounding box system is introduced to create a shape similar to the original character modeling without any professional skills.

The proxy plug-in tool allows the creation of a proxy with easy access and fast animation performance, which will help members focus on stories with better quality and expectations on different platforms.

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A rigging system was created that makes joints and controllers for character modeling to support the proxy plug-in tool but it is not described in this paper because this study only addresses the proxy modeling tool based on human-like bipedal characters.

II. Related Work

One easy way to convert a proxy geometry is to use tools embedded in 3D software. However, there are few tools on the market that automatically create previsualization proxy modeling, particularly proxy tools that can be used for school education. Furthermore, many processes are required to finalize proxy modeling necessitating manual corrections. These following tool example can speed up the previsualization process.

A. Morpheus Rig System

The Morpheus Rig System (MRS) [12] is a well-known tool for developing previsualization that uses various types of custom-generated modeling to create the optimal proxy characters to substitute the final character model. For example, some proxy rigs generated by MRS systems are mDrake, Wolf, Horse, Morphy Kid Base, Javelin, and Morpheus [13]. MRS offers the base template to modify the shape desired to match the character. The MRS is limited to a few characters and requires manual adjustment of the rig's base template to customize the form to fit the character using the provided MRS curve and control vertices (CVs) [14].

B. Advanced Skeleton

SkinCage in the advanced skeleton [15] is similar to proxy modeling, which creates a low-resolution shape at the joint location and binds to joints to implement movements. The primary purpose of the skin cage is to assist in weighting the final character effectively. Nonetheless, it is similar to the proxy character in that the simplified shapes move in sync with the final character. However, SkinCage is unsuitable for previsualization modeling and must be manually matched to the final modeling surface by selecting square-shaped controllers or vertices.

C. Retopology Plug-in

Retopology is classified into three types, manual, automatic, and wrapping methods, according to existing retopology software on the market.

First, to manually create a nice flow of the topology by editing the high-resolution mesh surface, software such as the 3Dsmax plugin ‘Topologik’, Blender plugin ‘RetopoFlow’, ‘TopoGun’, ‘3DCoat’, ‘Modo’, Maya’s built-in tools ‘QuadDraw’, ZBrush built-in tools ‘ZSphere’, and ‘Topology Brush’ are required [16]. Manually creating proxy characters with these software programs is concise and suitable for the intended characters, but it is inadequate for rapid creation and necessitates a lengthy procedure requiring professional skills.

Second, the automatic retopology software automatically creates a new proxy mesh from a high-resolution mesh surface, which can save time for static meshes, but it is not suitable for organic modeling, such as a human body that requires movements and considering the bending point [16, 17].

Third, the wrapping method matches an existing low-resolution geometry to a 3D scanned model or high-resolution geometry. A low-resolution mesh with a reasonable and smooth topological flow was adsorbed and wrapped around a high-resolution mesh. This wrapping method is different from manual and automatic methods, which do not create a new mesh on a high-resolution mesh surface but require an existing low-resolution mesh to perform the retopology operation.

D. Harmoni Fields Cage Generation and VR Technology

Casti *et al.* [17] proposed an automatic cage generation tool for animation. Their method starts with the high-res of the skeleton, and the users select the bending area, automatically create cross polygons where the character bends, create cage connecting vertices of those cross polygons, and finally inflate the cage matching the initial polygon, which is similar to the proxy plug-in tool. In addition, Casti *et al.* introduced a function over the curve skeleton to compute bending areas of abrupt changes in the character shape. However, using a mathematical approach to separate bending areas is limited. For example, an overweight character where the chin and neck meet or cartoony characters are often approached from an artistic point of view, requiring semimanual work.

In addition, Natural User Interfaces (NUIs) provide a new form using VR to work efficiently in the previsualization step [18]. State-of-the-art 3D tools usually come with typical icons, menus and pointer interfaces, which might be difficult to control for nonskilled users in the previsualization step. This can create primitive objects using mid-air gestures to manipulate and assemble into more complicated structures. However, there is a limit to directly producing proxy characters with VR systems. However, it seems possible to use the assets provided in this study to create an optimized pipeline for previs linked with VR in the future.

III. Algorithm

A. Basic Overview

There are not enough tools to create a proxy model that interacts with a rigged character in Maya. Therefore, in Fig. 1, this study developed a proxy plug-in tool for previsualization.

The proxy plug-in tool is designed using a bottom-up method rather than an existing top-down approach. The top-down method is the most commonly used approach for simplifying retopology high-resolution geometry. However, this study uses the bottom-up method, which starts with the low-resolution box-shaped bounding boxes, attaches them to each joint position, and then modifies the bounding box shape to fit the high-resolution shape (Fig. 1). The joints are created using the rigging tool developed in advance. Because this study focuses on proxy generation, the rigging tool method is omitted. First, the xform command and matchTransform command provided in Maya are used to match the distance between joints and joints and then the distance to the bounding box was applied. After matching the distance, a method from the Maya API [17] was used to match the bounding box shape thickness to the high-resolution geometry. In a simple case, the principle of proxy modeling is as follows. First, the bounding box objects are attached to each joint position. The number of vertices can vary depending on the shape of the final model. In this study, satisfactory quality and results were obtained when the number of vertices was 26.

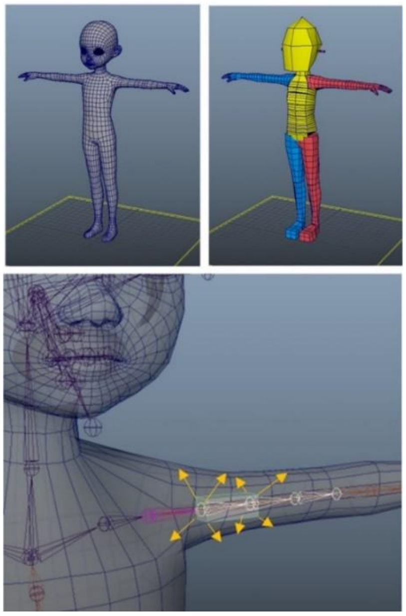

Figure 1. Proxy modeling plug-in tool.

Among these, the points that track the thickness at each joint position consist of eight points, and these points move along two axes to fit the thickness of the high-resolution object. Fig. 2 shows a simple example of a sphere.

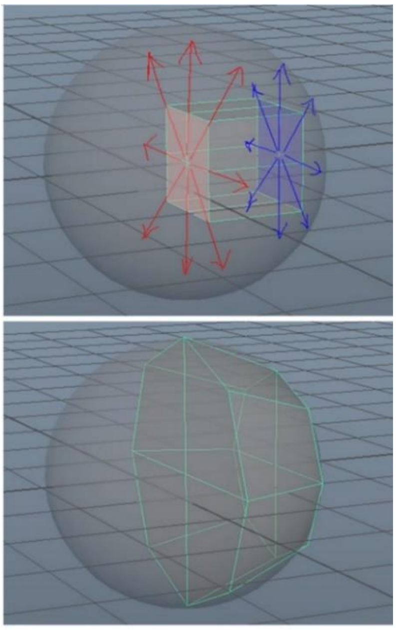

Figure 2. Proxy process example.

When a bounding box point is inside the high-resolution geometry, Algorithm 1 recognizes it as true and keeps moving the point along two axes until it perceives false when it is outside the geometry.

Algorithm 1. The thickness tracking method moves each point on the bounding box from each joint position until it reaches the outside of the geometry to copy the shape of the original geometry.

Algorithm 1. Thickness tracking method

1: $G \leftarrow \{g\text{: High} - \text{resolution geometries}\}$
2: $B \leftarrow$ minimum bounding box created along joint
3: $procedure\ SetVertexLocation(G,\ B,\ joint)$
4: $F \leftarrow \{plane\text{: planes of B to create the thickness}\}$
5: for $all\ f\ \in\ F\ do$
6: $\overrightarrow{center} \leftarrow$ center position of f
7: for $all\ \vec{v}\ \in\ f\ do$
8: if EXIST child of joint $then$
9: $\vec{c} \leftarrow$ corresponding child vertex of $\vec{v}$
10: if $|\vec{v}| > |\vec{c} \times \text{maxLengthRatio}|$ then
11: exit for
12: for $all\ g\ \in\ G\ do$
13: if $\vec{v}$ is in the inside of g $then$
14: $\vec{v} \leftarrow \vec{v} + \delta(\vec{v} - \overrightarrow{center})$
15: exit for
16: end for
17: end for
18: end for
19: $end\ procedure$

G represents the high-resolution geometries, and B represents a bounding box attached to each joint. The procedure in Algorithm 1(3) is to increase the vertex length on each bounding box face in a suitable small number of increments $\delta(\vec{v})$, whereas it reaches the outside of the geometry and then continues with the rest of the bounding box vertices in Algorithm 1(13:14).

Algorithm 1(13:14) tracking the thickness at each joint $\overrightarrow{center}$ may not work in certain areas. There is a problem with only the thickness tracking method at the joint location, depending on the shape of the high-resolution geometry. The character joint has a hierarchical structure, and the distance from the joint to the geometry may increase abruptly in some cases owing to the shape of the high-resolution geometry. For example, as shown in Fig. 3, the point marked with a red arrow on the shoulder will continue to increase downward, estimating the point inside the geometry.

Therefore, applying this method to various parts of the character modeling requires an additional setup, which requires an additional formula, Algorithm 1(10), so that the slope of the near edges, shown by the blue arrow in Fig. 3, cannot exceed a specific slope and limit the shape from each joint. This method suggests that the length of the vector tracking the thickness $|\vec{v}|$ is not greater than the slope of the length tracked at the child joint location $|\vec{c} \times \text{maxLengthRatio}|$. Maya's listRelatives command provides lists of hierarchy joints, which makes it easy to obtain the corresponding child vertex length $\vec{c}$, and the maxLengthRatio number can be arbitrarily set by the operator and through the heuristic approach of each character. The inclination value is easily calculated by dividing the distance between the joints by the thickness distance, measuring the decline of the near edges that are created first, and limiting the thickness of the bounding box shape. Applying Algorithm 1 to the thickness tracking method solves most problems.

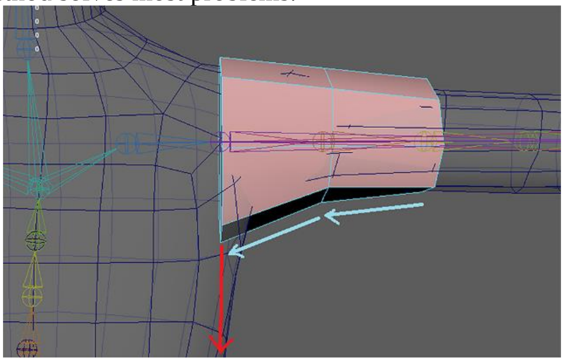

Figure 3. Specific area restrictions.

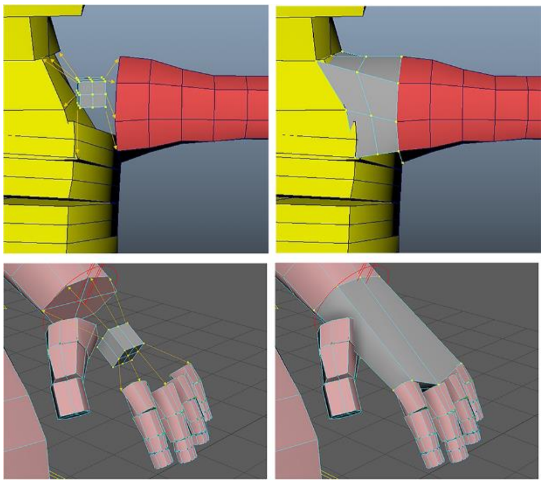

Figure 4. Multijoint area.

B. Head

The head part of the shape is significantly different depending on the character; therefore, applying only the thickness tracking method is not suitable for the head. Additionally, it is challenging to apply proxy modeling because there is no specific rule, and it is difficult to predict the shape of the head depending on the design. Therefore, guide tools were added where the jaw, nose, and ears were located in the rigging system to define the shape of the head using the thickness tracking method.

C. Multijoint Areas: Shoulder, Hip, and Wrist

Multijoint areas, such as the shoulder, hip, and wrist, also have limitations in the thickness tracking method to match the shape.

Because it is difficult to predict the exact shape of these multijoint areas, a new and easy method for creating these complex areas was devised. It can be easily solved by first creating surrounding proxy geometries using the thickness tracking method and then creating the multijoint shape by simply matching the shape points to the existing surrounding proxy geometries. It is easy to match because constant and unique numbers are provided to each bounding box shape. As a result, (Fig. 4), multijoint proxy shapes are easily created by single-joint proxies next to multijoint proxy shapes.

D. Finalizing Proxy Geometry

Finally, each bounding box at each joint location was combined as a proxy geometry. According to Dejeong [18], many separated polygons will make the engine slower because of simultaneously mass processing them. Consequently, it is good to combine objects into single meshes when possible. Thus, combining the bounding box as a proxy geometry will maximize the performance speed to the proxy character.

IV. Results

This research is examined in three parts using the proposed proxy plug-in tool: the processing method, animation operation speed, and shape output, with a total of five different characters. A creature character, a school project boy character, student graduation work the Ernaline character, a soldier character received from a modeling artist, and a commonly used online Mery [19] character were created using the components of various characters.

A. Processing

An independent character rigging tool was added to automate the proxy modeling process using the proxy plug-in tool. The character rigging tool makes it more manageable to set up the character using proxy modeling. The proxy modeling process automatically attaches to the current joint and helps minimize the number of steps. The advantage of this proxy plug-in tool method is that it does not require any complicated processes with fast performance. This method can proceed quickly without requiring additional intermediate steps.

B. Performance Speed

Computational speed is essential when working with animation. Therefore, performance speed is a critical factor for competing animators because the lag and slowdown in performance speed during work can cause inaccurate results. In particular, when the computation speed is fast, the movements of the crowd scene animation are also significant because they can perform complex tasks in a short time.

Table I compares the results of measuring the calculation speed between the proxy character created by the proxy plug-in tool and the original character and applies the same animation data to check the performance speed. The device specifications were as follows:

Processor: Intel(R) Core(TM)i7-6800K CPU @ 3.40 GHz
Ram: 64.0 GB
System type: 64-bit operating system, x64-based processor
Edition: Windows 10

The walking performance motion data was captured, cut into 240 frames and applied to the animation data for each character (Table I).

TABLE I. PROXY AND ORIGINAL CHARACTER OPERATION SPEED COMPARISON

Character Name	Proxy Character	Original Character
Creature	8.70 s	13.3 s
Boy	8.83 s	17.89 s
Bergfrue	8.69 s	11.43 s
Soldier	8.47 s	11.47 s
Mery	8.46 s	37.13 s

To distinguish the more elaborate calculation, the animation calculation speed was tested by applying ten for each character to the scene.

As a result, five of those proxy characters pursue an 8s, similar calculation speed, as shown in Table I. On the other hand, the original character animation calculations differ significantly depending on connections, polyfaces, deformation type, and several different functions. In the case of the Mery character, the speed difference is more than four times greater than when performing animation with a proxy character. All the other characters' animation operation speeds were also faster when working with the proxy modeling.

Without any complicated node connection, such as the original character, proxy characters produce a fast and consistent speed, optimizing the modeling with a simplified bounding box connection. However, proxy modeling might have slight calculation differences depending on the number of joints and character shapes.

Applying the systematic proxy plug-in function to each character with the same bounding box structure makes it possible to set the overall operation to a similar operation speed. Therefore, it is possible to effectively distribute the variable time required by different characters, which usually contain different calculation speeds. Animators are sensitive to every second and will be able to enhance the animation workflow if they can use the proxy plug-in tool.

C. The Shapes

A character that is too simplistic causes ambiguity in its form, which causes various problems [20]. For a proxy character suitable for previsualization, the work requires at least clear gestures expressed by the character movements and understandable motions intended for the story. Fig. 5 shows the results and comparison of the shapes of the original and proxy characters generated by applying the proxy plug-in tool to the five different characters.

As shown in Fig. 5, proxy modeling generates shapes according to their original character. The proxy modeling does not show accurate details, such as the original character, but displays a good understanding of the volume shapes of the character [21].

Furthermore, even though every single character modeling has a different shape, the new low-resolution bounding box system creates a consistent form of a bounding box at each character joint position with aligning edges, which makes it easy for animators to visualize the rotation of the arm, leg, and spine twist. However, the top-down approach is a method to create a shape similar to the original character by reducing the number of faces in high-resolution modeling, which does not consider the character joint location or the consistency of an edge loop dividing the faces as in this study.

This simplified output will help animators and artists who are untrained in the creation of a proxy modeling process during the previsualization steps [22].

The proxy plug-in tool can be downloaded at https://sbu1977.blogspot.com/.

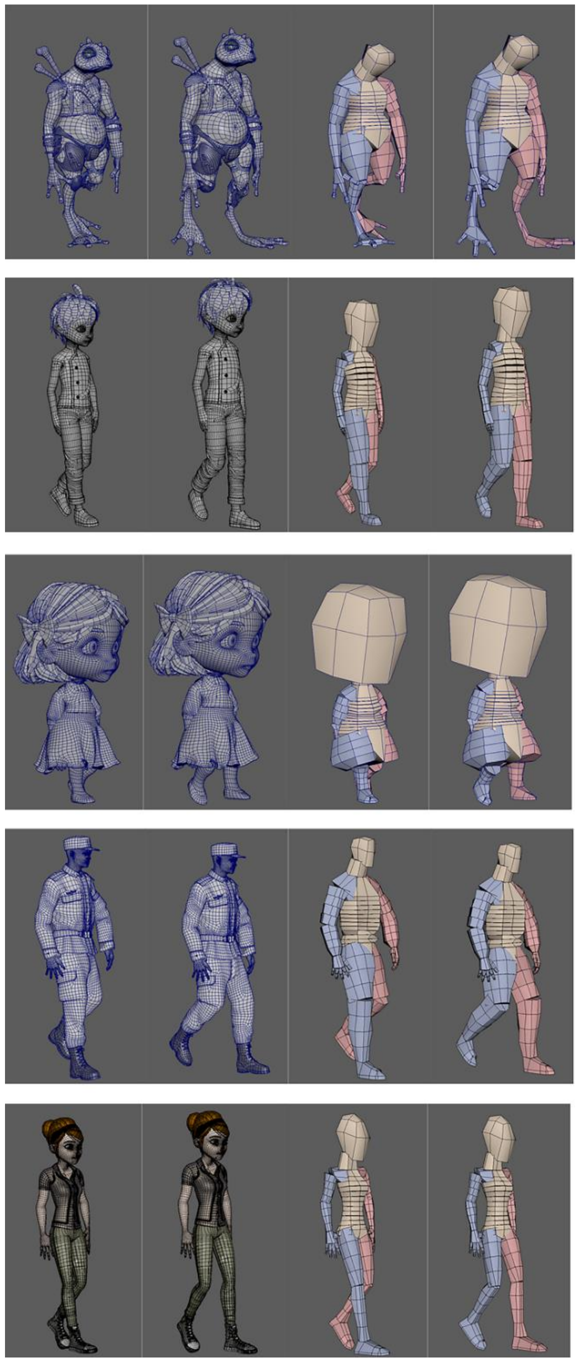

Figure 5. Original and proxy shape comparison.

V. CONCLUSION AND FUTURE WORK

In this study, a previsualization proxy plug-in tool was developed and applied to compensate for the uneasy production process. Proxy modeling is very useful not only for use in animation and VFX production but also for various industries such as the game industry and other related fields that desperately need low-resolution characters. This method creates an optimal low-resolution proxy model using a simplified bounding box.

The bounding box attached to each joint position is completely different from the previous method, which matches the bounding box shapes by tracing the thickness of the original character using my algorithm.

As a result, the proxy plug-in tool was easy to use, requiring only one click of a button. Furthermore, the animation operation speed was constant and fast owing to optimization with a simplified connection, which brings systematic management and reduces the risk of animation performance in the previsualization workflow. Moreover, the performance shapes were evident with consistent edge loops to easily identify problems by observing the lines or the shape of the bounding box when twisted on the spine, arm, and leg during the previsualization process.

However, this previsualization plug-in tool is inappropriate for creating facial details and emotions owing to the simplified bounding box shapes. Additionally, optimizing this proxy plug-in tool only for bipedal characters requires further research to address other types of characters, such as insects and animals.

Furthermore, with their lack of accurate head face shapes, proxy mapping techniques must be developed to generate outputs more similar to the final high-resolution modeling required in future work.

Conflict of Interest

The authors declare no conflicts of interest.

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References

[1] A. Beane, *3D Animation Essentials*, John Wiley & Sons, 2012.

[2] H. Liang, J. Sit, J. Chang, *et al.*, "Computer animation data management: Review of evolution phases and emerging issues," *International Journal of Information Management*, vol. 36, no. 6, pp. 1089−1100, 2016. DOI: https://doi.org/10.1016/j.ijinfomgt.2016.07.008

[3] H. K. Choi and S. H. Cho, "Development of effective pre-visualization authoring tool using conversion technologies—Based on film storyboard application," *Cluster Computing*, vol. 17, no. 2, pp. 585−591, 2014. DOI: 10.1007/s10586-013-0303-6

[4] M. Fink. (2003). A little history on previsualization. Animation World Network. [Online]. 25. Available: http://www.awn.com/articles/production/little-history-previsualization

[5] H. H. Wong, "Previsualization: Assisting filmmakers in realizing their vision," in *SIGGRAPH Asia 2012 Courses*, 2012, pp. 1−20. DOI: https://doi.org/10.1145/2407783.2407792

[6] J. A. Okun and S. Zwerman, *The VES Handbook of Visual Effects: Industry Standard VFX Practices and Procedures*, Routledge, 2020.

[7] N. R. Mansor, R. Zakaria, R. A. Rashid, *et al.*, "A review survey on the use computer animation in education," in *IOP Conference Series: Materials Science and Engineering*, IOP Publishing, 2020, vol. 917, no. 1, 012021. DOI:10.1088/1757-899X/917/1/012021

[8] T. Muender, T. Fröhlich, and R. Malaka, "Empowering creative people: Virtual reality for previsualization," in *Extended Abstracts of the 2018 CHI Conference on Human Factors in Computing Systems*, 2018, pp. 1−6. DOI: https://doi.org/10.1145/3170427.3188612

[9] M. Nitsche, "Experiments in the use of game technology for pre-visualization," in *Proc. the 2008 Conference on Future Play: Research, Play, Share*, 2008, pp. 160−165. DOI: https://doi.org/10.1145/1496984.1497011

[10] T. Muender, G. Volkmar, D. Wenig, *et al.*, "Analysis of previsualization tasks for animation, film and theater," in *Proc. the 2019 CHI Conference on Human Factors in Computing Systems*, 2019, pp. 1−6. DOI: https://doi.org/10.1145/3290607.3312953

[11] H. Bhattacharya. (2013). Modular rigging tools for Maya. [Online]. Available: https://www.highend3d.com/maya/script/modular-rigging-tools-for-maya-fully-open-source-for-maya

[12] J. Carey, B. Clark, and C. Moore. (2019). Rigging, Dojo: Teaching the art and science of character rigging. [Online]. Available: https://www.riggingdojo.com/home/morpheus-2/

[13] B. Josh. (2018). CG Monastery: Proxy. [Online]. Available: http://www.cgmonastery.com/category/assets/rigs/proxy/

[14] B. Josh. (2018). CG Monastery: Intro to proxy rigs. [Online]. Available: https://www.cgmonastery.com/2018/09/intro-to-proxy-rigs/

[15] O. Nostdal. (1999). Advanced Skeleton: Maya rigging tools. animation. [Online]. Available: https://www.animationstudios.com.au/advanced-skeleton

[16] Y. Yan, "The study to improve re-topology efficiency between analyzing software and making examples of different types of 3D models," *The Journal of the Korea Contents Association*, vol. 20, no. 6, pp. 9−25, 2020. DOI: https://doi.org/10.5392/JKCA.2020.20.06.009

[17] S. Casti, M. Livesu, N. Mellado, *et al.*, "Skeleton based cage generation guided by harmonic fields," *Computers & Graphics*, vol. 81, pp. 140−151, 2019. https://doi.org/10.1016/j.cag.2019.04.004

[18] R. Malaka, T. Döring, T. Fröhlich, *et al.*, "Using natural user interfaces for previsualization," *EAI Endorsed Transactions on Creative Technologies*, vol. 8, no. 26, p. e5, 2021. DOI: 10.4108/eai.16-3-2021.169030

[19] MFnMesh Class Reference. (2011). OpenMaya − API module for common classes, functionset classes. [Online]. Available: https://download.autodesk.com/us/maya/2011help/API/class_m_fn_mesh.html

[20] S. D. Jong. (2006). Hourencescom RSS: Houreces. [Online]. Available: http://www.hourences.com/tutorials-mesh-rendering

[21] J. M. G. Alvarez and A. F. M. Lora. (2014). Mery Project. [Online]. Available: https://www.meryproject.com/

[22] G. Caumon, P. L. C. D. Collon-Drouaillet, C. L. C. D. Veslud, *et al.*, "Surface-based 3D modeling of geological structures," *Mathematical Geosciences*, vol. 41, no. 8, pp. 927−945, 2009. DOI: 10.1007/s11004-009-9244-2

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