

Phased Expression Technique for Realistic Embodiment of Tiger Fur

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Abstract

In recent Hollywood movies such as <Dawn of the Planet of the Apes, 2014>, <The Hobbit, 2014> etc, animal-shaped CG creatures are being realistically presented. Materialization of fur serves as an important factor to give each character distinctive features as well as particularly describes CG creatures more realistically. In case of major studios, the fur effect is materialized by using in-house tool or through their own R&D. In most studios, however, the effect incurs technical and financial difficulties. This study, therefore, is to suggest an effective fur making technique using five plugins through experimental research. For this research purpose, this study first draws existing technical limitations and problems through literature review on fur making using CG and case studies of movies. Second, this study establishes optimized work process based on the limitations and problems by utilizing features of general plugins on three steps of ①Fur shape modeling, ②Fur dynamics or animation and ③Fur rendering as a technical method for realistic expression of fur and analyzes its technical utility. Through this procedure, it is to present an effective way of working and it is considered as a useful research that can be applied to projects of studios in general.

Keywords: Realistic Fur, Fur Effects, Animal Characters

1 Introduction

1.1 Background and Purpose

In the movie production field, development of computer hardware and software enables materialization of many scenes that cannot be expressed into actual images in CG manner. Fur materialization in recent movies in which CG is given a lot of weight serves as an important factor to give each character distinctive features as well as particularly describes CG creatures more realistically[1]. Movies such as <King Kong, 2005>, <Dawn of the Planet of the Apes, 2014> with animal-shaped digital creatures as its main character and <Mr. Go, 2013> which was made only with domestic technologies cannot be produced without technical support for fur making. Big studios like Weta Digital or Dexter are constantly developing technologies for realistic embodiment of fur and they have come to possess independent software in-house tool. On the other hand, general studios need to utilize general plugins for fur materialization but they have limitations in advanced technical expressions[2]. Thus, this study is to suggest an effective method for realistic fur materialization of animal-shaped digital creatures that can also be utilized in general studios.

1.2 Scope and Method of Study

Realistic embodiment of digital creatures requires numerous steps and processes including production modeling, Fur FX, lighting, rendering, compositing, etc. Among various processes in production, the scope of this study is Fur FX only

and it covers object creation and option adjustment of fur; simulation through animation and; a part of shading and rendering. For this research purpose, this study first draws existing technical limitations and problems through literature review on fur making using CG and case studies of movies. Second, this study establishes optimized work process based on the limitations and problems by utilizing features of general plugins on three steps of ①Fur shape modeling, ②Fur dynamic or animation and ③Fur rendering as a technical method for realistic expression of fur and analyzes its technical utility.

Table 1 Research Sequence

Research Questions	Is it possible to materialize realistic fur by utilizing general fur making plugins?
Preceding Research	- Literature review on fur making in CG - Case studies of movies on which fur is materialized
Analysis Criteria derived	①Fur shape modeling ②Fur dynamic or animation ③Fur rendering
Experimental Research	Tiger fur materialization by utilizing plugin based on each step of analysis criteria
Conclusions	Materialization of realistic fur

2 Preceding Research

2.1 Production Process of Fur in CG

Fur lexically means hair, pelt or faux fur and it is used as the same meaning in terms of results of rendering in movie production. Its making process is included in Effects Animation and called Fur FX(Effects) as shown in the pipeline on Figure 1.

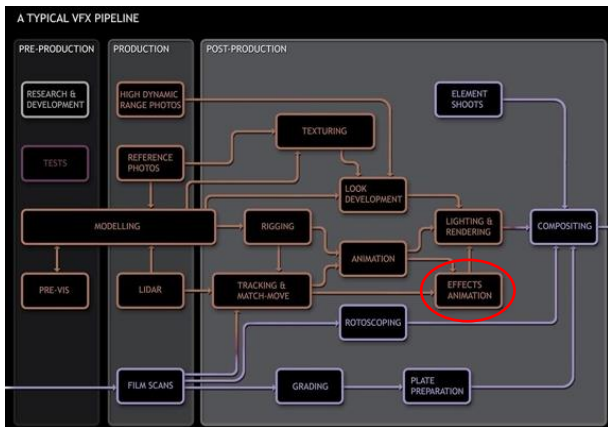


Figure 1 The Visual Effects Pipeline[3].

The process to materialize fur on 3D generally is modeling → fur making by object unit → adjustment of various options such as fur type, direction, density, length, etc → color → rendering[4]. Magnenat-Thalmann et al.(2000) defined this phased fur materialization as the following three main stages. 'One can conceive three main aspects in hair simulation – hair shape modeling, hair dynamics or animation, and hair rendering' [5]. And this can be summarized as in Table 2. With this phased materialization process as analysis criteria, this study checks the current production technology tendency of Fur and examines features of movies in which Fur is realistically materialized.

Table 2 Three steps of realistic fur materialization

1. Fur shape modeling	2. Fur dynamics or animation	3. Fur rendering
Step to adjust shape and options of fur	Fur animation and dynamic depending on movement	Process to realistically visualize fur considering the surroundings

2.2 Technology Tendency of Fur

The initial materialized pattern of Fur that used CG has been produced in the form of texture map as seen in games[6]. This has the merit of fast materialization in the low performance but has the limits when it comes to Fur dynamics or animation and Fur rendering, therefore it is not proper for realistic expression. Various techniques to express Fur shape since have been developed and there are implicit method that expresses Fur as volume model and explicit method that expresses a strand of Fur as curved cylinder, which is widely

used now in CG[7]. In case of Fur dynamics, even though there are many things to calculate and complexity, mass-spring dynamics method is generally used because it is easily combined with other physical systems. And here interpolation method is applied in the minimum Fur to improve for the optimized directions[8]. Fur rendering is divided into the expressions of shading of Fur and shadow of Fur. For shading, tangent method of Kajiyia is mainly used but it cannot express exactly the scattering of light inside Fur and has some limitation to realistic expression[9]. To make up for this, Fur model of Marschner that materializes the quality of real hair and has the exact reflection was developed, and a reflection model which applies multiple scattering is recently being studied[10]. For shadow, reflection and refraction can be materialized in shading treatment, so deep shadow through global illumination makes realistic shadow materialized. Such methods were already standardized in large studios and they are now being improved by the optimized direction of pipeline[11]. And it is focused that artists could make more intuitively and effectively through grooming of Fur and simulation and real-time rendering.

2.3 Relevant Case Studies about Making Fur

As Jang Seongran(2013) stated that 'Technology to naturally draw fur using CG is an advanced technology that is exclusively possessed only by a few enterprises among ones on visual effects in the world' [12], realistic embodiment of fur is an advanced technology that requires long-term R&D. <Futureworld> of director Richard T. Heffron which first applied 3D graphics to a real image movie was produced in 1976[13]. But materialization of fur on digital creature through CGI technology was not possible until 1994, eighteen years afterward.



Figure 2 Kitty in <The Flintstones, 1994> (left), Monkeys in <Jumanji, 1995> (right)

The left on Figure 2 is a scene where Kitty appears in <The Flintstones, 1994> in which fur was first applied[14]. Due to the limits to the materialization technique of CG at that time, Fur is little seen in the movies and is only presented in the night scenes and also the size of characters takes small percentage in the screen. Based on <the Flintstones, 1994> and the results deduced from the previous literature research, three steps of the realistic materialization of Fur were analyzed. When analyzing Fur dynamics or animation of the step 2, the movement of Fur according to motions of Kitty is not materialized, hence Fur shape modeling of the step 1 is not made in the form of curve or cylinder but materialized in the form of texture map. For Fur rendering of the step 3, shading of Kitty is materialized as local shading that does not consider surrounding environment and as a result, it has the limit to

realistic expression. Another study on fur argues that <Jumanji, 1995> on the right of Figure 2 is the first movie on which realistic fur is materialized[15]. It can be analyzed that way because the digital creatures of monkey and lion play bigger roles on <Jumanji, 1995> than Kitty on <The Flintstones, 1994> and the dynamic on the second step of fur materialization is partially applied. Figure 3 is a sequence of monkey's riding a bike and it shows dynamics or animation of fur with air friction. This indicates that Fur shape modeling of the step 1 is not produced as a simple texture map but rather is materialized by applying a fundamental pattern of curve in order to express realistic Fur. As to rendering, the third step of fur materialization, however, it has limitations due to unrealistic local shading as in <The Flintstones, 1994>.



Figure 3 Sequence of monkeys' riding a bike in <Jumanji, 1995>

As CG techniques have been generalized further with rapid development of hardware and software since 2000s, there have been great changes in movie production as well. The left and the right on Figure 4 are scenes in <King Kong, 1976> of director John Guillermin and in <King Kong, 2005> remade by Peter Jackson. Since it was impossible to materialize a digital creature in 1976, a 16-inch-tall miniature was made and the movement was expressed through stop motion technique[16] or make-up and filming techniques with special effects were adopted for production.



Figure 4 <King Kong, 1976> (left), <King Kong, 2005> (right)

<King Kong, 2005> reborn as digital creature became an issue for fur materialization as realistic as that of a real gorilla. It is the result after the first and second step of realistic fur materialization was performed by utilizing in-house tool named Bonobo by Weta digital studio and then rendering on the third step was done through PRman of Renderman developed by Pixar[17]. Features of each step are analyzed as follows.

Step 1. Fur shape modeling

Fur is produced by utilizing methods of painted maps and guide curve system and Per-vertex & IFF maps for different body parts of the model. Grooming of fur adjusts various attributes <options> of the fur through deformer overlap and wire deformers[18].

Step 2. Fur dynamics or animation

Dynamic of fur is materialized through dynamics and animation. Except for scenes that require materialization of

various dynamics such as when fur is soaked or smoke needs applying, the thick and stiff fur of King Kong is expressed through animation by binding on the creature's surface of body[19].

Step 3. Fur rendering

Reflex model shading is adopted which enables physical based rendering of Marschner method which is based on perception that when real hair is observed with a microscope, the hairs are of a thin single-layered structure and a translucent refractive index[20] and; soft and translucent shadow is created through deep shadow map method.

2.4 Analytical Tools

Table 3 Feature of fur materialization steps through case study of movies

Film Production Case Studies	<The Flintstones, 1994>	<Jumanji, 1995>	<King Kong, 2005>
Fur materialization software	(unknown)	(unknown)	Bonobo, Renderman
Features about Three steps of realistic fur materialization	Step 1. Fur shape modeling	Texture map type simple Fur was produced.	Curve type Fur was produced for realistic materialization.
	Step 2. Fur dynamics or animation	It was texture map type but dynamics was not materialized in it.	Fur was partially applied.
	Step 3. Fur rendering	Realistic rendering was not materialized because only local shading was applied nor considering its neighbor environment.	Realistic rendering : - Shading of Marschner method - deep shadow map

To summarize features of three steps for fur materialization through the aforementioned three cases of movies, ① shapes and various options of fur that can be intuitively controlled, ② application of fur animation and dynamic for character's movements and ③ materialization of shading and shadow for physical based rendering.

3. Experimental research

3.1 Analytical Tools: General Plugin for Fur

Materialization

Three steps for realistic fur materialization are to be applied through general plugins. First, the general plugins are classified as in Table 4 and among them, five of Maya Fur, Shave&Haircut, Zbrush Fibermesh, Peregrine Yeti and FX Hair are selected. The selection criteria is ① whether the plugin is frequently utilized, ② whether 3D Maya can be supported which is used by multiple movie production

enterprises and ③whether various render software is supported. Though FX Hair cannot perform the first step of Fur shape modeling and the third of Fur rendering on phased materialization for its own plugin, it is included in this experiment for its frequent use of dynamic on the second step.

Table 4 General plugin for fur materialization

Plug-in	Software Compatibility	Features	Support Renderer
Maya Fur	3DMaya		Renderman, Mentalray, Vray, Arnold
Shave&Haircut	3DMaya		Renderman, Mentalray, Vray, Arnold
Zbrush Fibermesh	3DMaya, 3DMax	Specialization about fur making and grooming	FiberMesh Render
Peregrine Yeti	3DMaya		Renderman, 3delight, Vray, Arnold, Guerilla Render
FX Hair	3DMaya	Specialization about dynamic	-
Ornatrix	3DMaya, 3DMax		Mentalray,Vray
Hairtrix	3DMax		Mentalray,Vray
Cinema Hair	Cinema4D		Arnold,Vray,mentalray,Renderman
...			

3.2 Subject and Process of Experiment

Tiger creature modeling is conducted by utilizing 3D Maya2015 software as in Figure 5. The reason why a tiger is selected is that an intuitive experiment can be implemented on fur with various patterns, lengths and shapes. The experiment consists of three steps which are: to select the most appropriate plugin for realistic expression on the first step of Fur shape modeling and; to conduct experiment on dynamics or animation as the next step by using the most appropriate plugin.

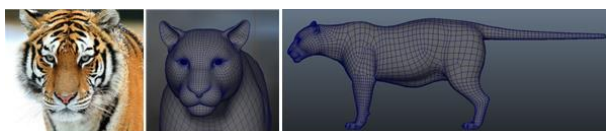


Figure 5 Creature subject to modeling (center), (right) based on the picture of actual tiger (left)




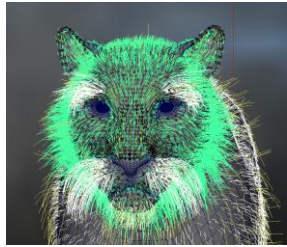
When using a particular plugin, overlapping application of another plugin generally incurs an error. When data cached value of a particular plugin is extracted using guide curve, however, dynamic can be materialized. After selecting an appropriate plugin on the second step through this procedure,

the final Fur rendering on the third step is experimented with render shader that is supported by the initially selected plugin.

3.3 Experimental Research 1: Fur Shape Modeling

Table 5 is the result of applying Fur shape modeling by utilizing plugins. First, materialization through Maya Fur has limitations for realistic expression due to the sole fur creating method (face application), limited fur option adjustment and unintuitive grooming. Second, materialization through Shave&Haircut has two fur creating methods (face application, guide curve), various fur option adjustment and intuitive grooming but it incurs loads on system when the number of fur increases. Third, materialization through Zbrush Fibermesh is of one fur creating method (mask), various option adjustment and relatively free to system specifications with quick grooming but its intuitiveness lacks regarding materialization of various types of fur in a narrow scope like a tiger. Last, materialization through Yeti has various advantages with three fur creating methods (face application, guide curve, density map), various option adjustment through node method and attribute method and intuitive grooming and further, mel script can also be applied upon. FX Hair is a plugin of materializing dynamic only so it is omitted from this process.

Table 5 Fur shape modeling by utilizing different plugins

	
A. Maya Fur	B. Shave&Haircut
	
C. Zbrush Fibermesh	D. Yeti

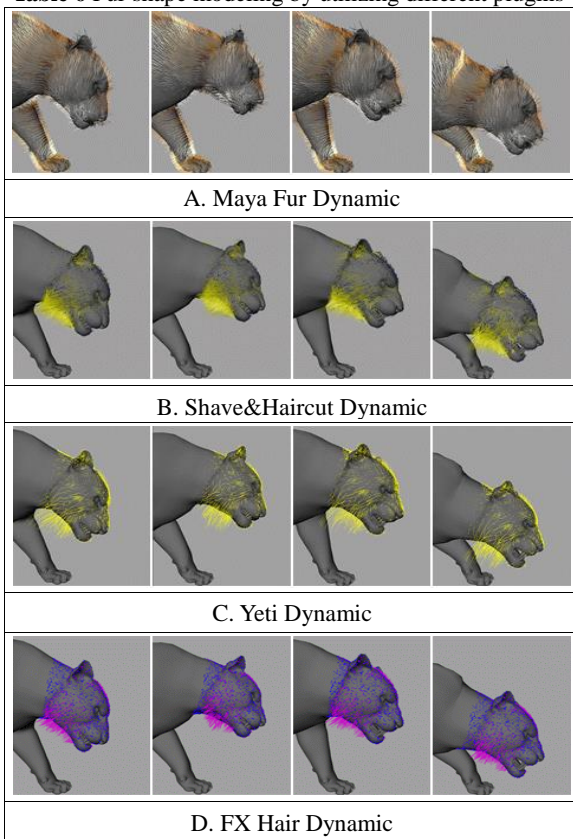
In terms of materializing tiger's fur as the first step of Fur shape modeling, Yeti plugin is analyzed as proper one with intuitive fur making, grooming and various option adjustment.

3.4 Experimental Research 2: Fur Dynamics or Animation

The next is to apply another plugin to apply dynamic on fur which is produced by using Yeti on the first step. First, acting is applied to creature based on a scene with a running tiger. A camera is set to capture upper body including its head from the side and to move in the same direction as that of creature to

enable analysis on dynamic process of fur. Cached value of fur created by using Yeti plugin is extracted by guide curve and an experiment on dynamic is conducted as in the Table 6. First, dynamic materialization through Maya Fur facilitates quick application through hair system dynamic but it take a long time to process application of Maya fields(air, drag, gravity, newton, turbulence etc). And the result and outcome of dynamic does not match and, consequently it incurs low intuitiveness, which is not appropriate for realistic expression. Second, Shave&Haircut is of quick and precise processing Maya fields and dynamic(collison, self-interaction) of short fur like that of a tiger but it requires long computing time to process long fur, for example, on the jaw. Third, Yeti dynamic is of superb intuitiveness as it is materialized through application of guide curve, which is identical with that of grooming process. However, as movements of numerous fur subject to the guide curve cannot be delicately controlled, it has limitations on realistic expression. Last, FX Hair demonstrates high calculating speed of dynamic even though tiger's numerous fur is materialized and it shows realistic movements of fur depending on the tiger's move through various options (Maya field, collision, self-interaction, goal curves). Zbrush Fibremesh is a plugin specialized in Fur shape modeling and it is omitted from this process.

Table 6 Fur shape modeling by utilizing different plugins



Through the second experiment, it is concluded that FX Hair plugin is of high appropriateness with high processing speed on dynamic and superb interactive between fur and various options including Maya fields, etc.

3.5 Experimental Research 3: Fur Rendering

The last is to materialize realistic fur through applying shading and rendering on fur. Yeti plugin selected through the first step of Fur shape modeling supports shader and rendering of Vray, Renderman, 3delight, Arnold and Guerilla Render. Among them, Arnold, 3Delight and Guerilla Render are excluded from this experiment for their low utilization. Table 7 is the result from applying 3.92 million pieces of fur by using MtlHair shader of Vray and Renderman RIS shader and performing rendering. Rendering result through V-ray expresses reflection of realistic fur shading of physical based rendering on the basis of Marschner Fiber Model. Materialization method of shadow is a ray reverse tracing of raytrace[21] and it shows high calculating speed by reducing unnecessary calculation other than camera rays but compared to shadow of Renderman, it has a weakness that the materialized shadow is flatter than that of Renderman. Renderman also expresses reflection of realistic fur shading based on Marschner Fiber Model. The shadow materializing method is a bi-directional ray tracing one of path tracing and more realistic fur is materialized as PBR-based shadow expression by calculating not only camera rays but shadow rays[22]. Regarding speed, however, it requires long computing time compared to that of V-ray. Through the Fur rendering experiment as the last step, it is concluded that V-ray which swiftly materializes realistic fur shader on the basis of physical based rendering is of high appropriateness in effective fur making. Regarding the shadow expression, Renderman renderer is capable of more realistic expression but it requires long computing time, which is inappropriate for production of small-scale projects.

3.6 Findings

Among three steps for realistic fur materialization, the first Fur shape modeling is materialized through Yeti plugin that is with superb intuitiveness of fur making and that can adjust various shapes and options in grooming process. On the second Fur dynamic or animation process, movements of realistic fur are materialized based on animation of tiger creature through FX Hair by caching fur produced by Yeti and then importing as guide curve. On the last third step, rendering is conducted on a tiger through materializing translucent realistic shader through VrayMtlHair on the basis of physical based rendering of Vray. The three experimental steps for realistic and effective fur materialization can be summarized as Table 8.

4. Conclusion

Production of animal-shaped digital creature is increasing not only in movies but also in small-scale projects. Materialization of fur serves as an important factor to give each character distinctive features as well as particularly describes CG creatures more realistically. Realistic fur materialization in CG, however, requires long-term R&D and expenses, which incurs technical and financial difficulties to small studios. Thus, this study intends to materialize realistic fur of tiger creature through experimental research. For this research purpose, the study first conducts literature review on fur making using CG

and analyzes phased process for fur materialization and its feature. Second, it applies characteristics of general plugins to the three steps of ①Fur shape modeling, ②Fur dynamics or animation and ③Fur rendering as a technical method for realistic expression of fur and produces effective fur. This study approaches the experimental process of every phase in quantitative ways and analyzes the result numbers as shown in

the Table 7. This study, therefore, aims to suggest an optimized method for realistic fur making of digital creature through a phased experiment. The experiment is regarded as significant for presenting possibility of applying fur expression not only in Hollywood-scale movies but also in small-scale projects.

Table 7 Using Vray shader and Renderman shader for Fur rendering



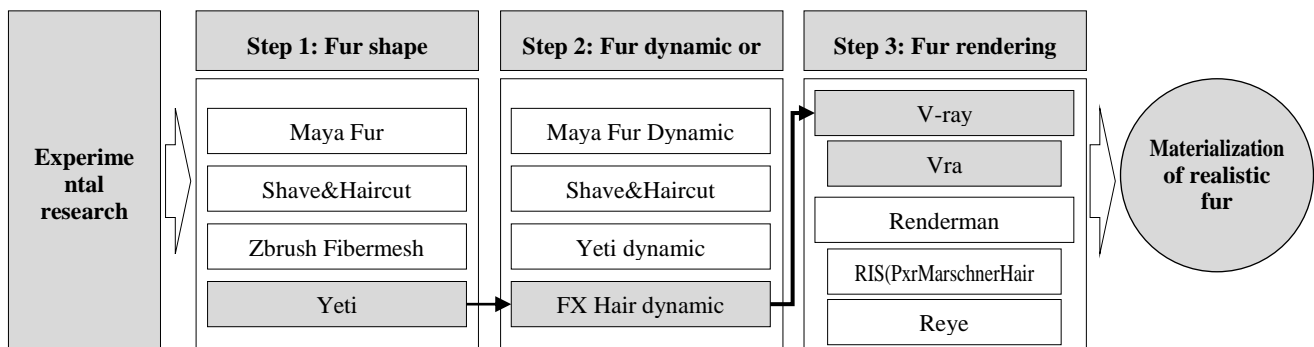
Renderer and Shader	V-ray VrayMtlHair	Renderman RIS(PxrMarschnerHair)
System	CPU: Intel Core i7-5960X 3.00GHz / Memory: 128GB / GPU: Geforce GTX 980 OS: Windows 7	
Software	Maya 2015 / Yeti v1.3.18 / V-ray for Maya 2015	Maya 2015 / Yeti v1.3.18 / Renderman 20.4
Final Output		
Features	Render Time: 1 hour 12 mins Resolution: 720p	Render Time: 15 hours 20 mins Resolution: 720p
	Fur amount: 3.92 million	
	Image Sampler Adaptive Min Subdivs: 1 Max Subdivs: 64 Threshold: 0.005	Sampling Max Samples: 256 Pixel Variance: 0.005
	Opaque for Shadows: Off Opaque for GI: Off	-
	GI Primary Engine: Brute Force (default settings) Secondary Engine: Light Cache (default settings)	Integrator Path Tracer Max Path Length: 10 Sample Mode: bxdf Light Samples: 8 Bxdf Samples: 8

Table 8 Process of experimental research



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