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Rigging feathers and scales on deformable geometry by reversing the hierarchy and parenting bones to the mesh

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Introduction

Rigging feathers, scales, quills, tentacles, or other objects that are connected on a deformable part of the mesh, such as the neck, spine, tail, or soft body can be a hard task, since trough the deformation no steady anchor point for the bone remains. This problem becomes especially clear when the target mesh, the bones should connect to, are simulated, have no bone structure in general or move in unique or unrealistic ways. This causes objects to slide around and into the skin. This phenomenon will be called "sliding" in this paper.

For example: A dragon with big, distinct feathers along the neck and spine, that should be controllable to show emotion. If the neck is bend down, the bones that control the feathers, move exactly relative to the vertebrate bone they are connected to. The skin, however, is weight painted. This means, while part of the neck bends with a fallout in its proximity, the feathers move in full relation and would visually detach from the main body or slide across it. This is seen during a walk animation in Fig 1 and 2, which are the the back plates of a stegosaurus from the game ARK: Survival evolved. The spines slide out of their sockets, which are marked with the red line.

CG-Breakdowns or making offs hardly show the character rigs that were used. Sometimes it is possible to get a glimpse at the animation rig, which has all mechanical bones hidden and only shows what the animator is supposed to see. But the actual rig and rigging mechanics are rarely discussed. When looking at 3D characters it can only be guessed what techniques were used to properly rig scales, feathers, and other objects.


Fig 1


Fig 2

Goal

This paper strives to find a general solution for the problem. It analyses animals to find a relevance to why this problem should be addressed. Then it looks at 3D characters from various movies and games to identify possible techniques and methods being used to counteract spikes, plates, quills and other sliding over or into a deformable mesh. Here it is important that the feathers remain freely deformable while moving correctly across the mesh. Not only should the feather behave correctly, but also the bones that make the deformation happen need to follow correctly.

This paper tested methods mainly refers to information and mechanics used in the free 3D software Blender but might be used as general knowledge, since 3D has certain similarities across softwares.

Each method is tested on how far the feathers move across the mesh in animation.

Even though in the industry there seems to be solutions already in use but he topic is hardly talked about and this paper recommends further research.

Background & Motivation

Creature characters are often inspired on real-live animals. For example, Dan Katcher states in an interview that the dragons from Game of Thrones were inspired by animals such as the sun gazer lizard, Tyrannosaurus Rex, bats, and birds. [1] (How The 'Game of Thrones' Dragons Were Designed (Insider 2019)). To better approach the problem with rigging parts of a character on deformable sections of the mesh, I will look at some real-live animals where this problem could occur if they were to be used as inspiration or be recreated in the 3D world. The animals belong to unique groups and have all different bodies. To find a general solution it is crucial to understand the different needs character rigs might have. I found similarities in the spikes of a cuttlefish and the spikes on the dragon Stormfly from the How to train your dragon franchise Which shows a good example how spikes on deformable surface of an animal is transferred to a creature design.

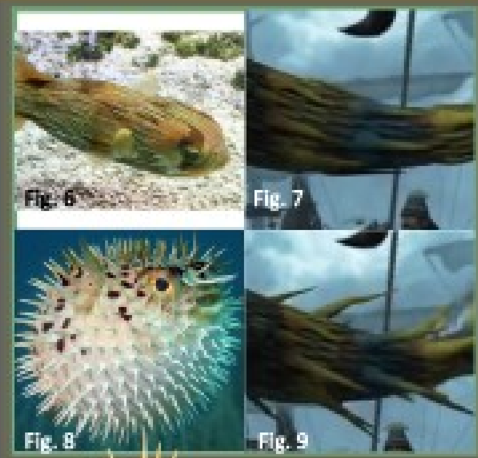
Fig. 6 Fig. 7 Fig. 8 Fig. 9


Fig. 10

Also look at creatures in movies and games so see if the sliding problem occurs there too and to analyse what solution might have been used. In Fig. 3 and 4 the animation rig of the dragons from Game of Thrones is seen. Notice how the frilled spikes along the neck and tail are a separate mesh and seem to be rigged as well. Upon closer inspection (going through the shot frame by frame) no sliding problem seem to occur. Not even the animation controls are changing position across the deformable mesh. These facts make it likely that the bones to control the frilled spikes are somehow parented to the deformable mesh.


Fig.3


Fig. 4

Approach

Now to test the theory about parenting the bones to the mesh, I created a rig for a dragon character in blender. The dragon model and texture were made by my bachelor project team member Carina Heller.

possible solutions were tested that could have been used in the shown examples. Each time a scale on the texture is marked red to indicate how far the feathers move in the animation. The further the feather moves from the red marked scale, the worse the problem becomes. At the end I will use the method that worked best and try to improve on it.

1. Method: Parenting the feathers to the rig with automatic weights, the standard way. This serves as indicator if the other methods work or go into the wrong direction. The main problem with this is that the feathers can slide across the surface and even shrink as is seen in Fig. 11 And 12.


Fig. 11

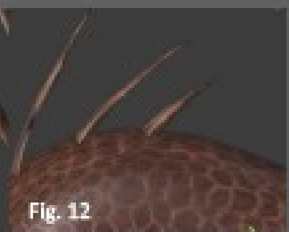
Fig. 12

2. Method: Vertex groups were created on which the feathers are parented to. This properly attaches the feather but the orientation behaves unpredictable. The distance between the red marked scale and feather do not change in the animation, but at a certain point the feathers will flick into seemingly random directions. Also a vertex is each needed where a feather is located.

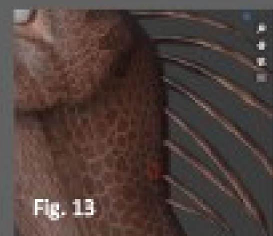
Fig. 13

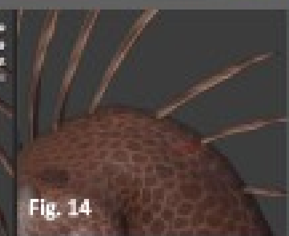
Fig. 14

3. Method: A particle system, which lets the feathers move and rotate correctly but offer little control over single feathers. To place the feathers in a particle system exactly the way they were before can be time consuming. Also this can greatly hinder the design process, were the artist wants to place feathers with care and precision. A particle system is not always transferrable between softwares.


Fig.15


Fig. 16

Proposition: Parenting bones to vertices and use them as anchor point for a rig set up

The second method worked best towards the papers problem. Having an anchor point on the mesh is the basis for the following set up. Since the rotation behaves unpredictable, only the location of the bone can be used. This way we always know where the feathers should be located on the deformed skin when it is animated.

To gain the correct rotation, I created a bone that is parented to the nearest neck vertebrate bone. This bone is the number 2 on Fig. 5. This bone has a constraint that makes the bone to always stretch to the bones parented to the vertices, which are number 1 on Fig. 5. Now a relation between neck and skin is made, where location and rotation data are being generated. The bones labelled number 3 on Fig.5 are the bones used to control and deform the feathers. These bones are parented to the number 2 bones tails, which point to the exact same location as the number 1 skin bones. In this state the feathers move correctly but do not rotate at all. What is left to do is to apply a constraint to the feather bones (number 3) which copy the rotation from the stretched bones (number 2). In Fig. 5.

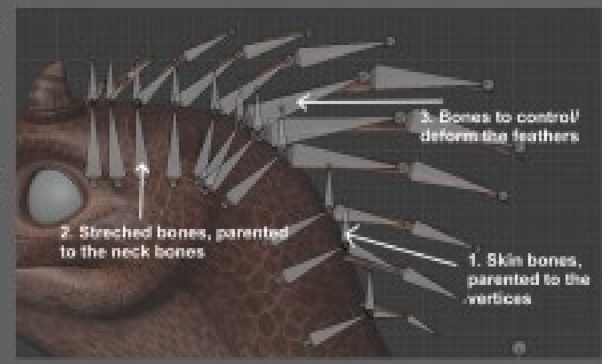

Fig.5

Evaluation

Parenting bones to the mesh works for character features such as the dragon, used in the tested methods, with the feathers. Bigger objects (like feathers, quills, and scales), where sliding and other unwanted behaviour can break the immersion, profit from this method. If there are still errors occurring, every feather is freely moveable and single feathers can be adapted. As long as this remains in a small scale and will not affect all other objects in its proximity this is something that can be worked with.

There are some downsides though. Every vertex needs to be assigned to its own group, and every object needs at least 3 bones in this setup, where it must connect to said vertex group. This is a process that is not easily automated and can be tedious, especially when there are over 70 feathers on the character. For this set up to work the most perfect, it is required to have vertices on the body mesh where each object is located. This can easily make rigging the character harder, or mess with the topology.

The dragon rig shown in the methods ended up having around 72 feathers on the neck, which is hard to organise. Each feather needs 3 bones, which means there are 216 bones in total just for the feather set up. The nearest vertex was used to parent the feather, but this might result into slight aberrations. This

Conclusion

It highly depends on the character if such a rig set up is needed. If features like feathers or scales should not move, then simply weigh painting can suffice. Similar applies to characters, that have many feathers or quills. Then a particle system could be the right choice, but then it can still be argued that some bones could still be parented to vertices to ensure the control bones move equal to the particles they are supposed to control.

It seems that this problem is somewhat addressed in the industry, since two out of three example character had no sliding. Having scales, feathers, quills, and other features on deformable mesh seems to be an issue creature characters are facing the most. This could be because humanoid characters often do not possess a long neck or tails and the fact that most of the features could be inspired from the animal kingdom.

Considering the low numbers of examples and no official insights to the mechanical side of the used rigs this paper servers as a direction to the topic. Further research and understanding can lead to more exact and efficient ways to rigging.

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