A Unified Dynamics Pipeline for Hair, Cloth, and Flesh in *Rango*

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Figure 1: *Characters in* Rango *were exposed to a full complement of deformable sims, from cloth to hair and flesh.*

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1 Introduction

The visual effects pipeline for a fully animated CGI character requires the application of several layers of dynamics. Simulation of muscles, skin deformation, hair or fur, feathers, and multiple layers of clothing are all required. This is a very difficult task but one that is made manageable by a full featured dynamics engine like PhysBAM. Deformable objects like cloth, hair, and flesh can all be simulated with similar controls and integrated into the same workflow.

2 Grand unification of deformables

We present a unified pipeline for simulating deformables like cloth, hair, and flesh. Each of these are vastly different physical systems, but each one can be effectively simulated with a mass/spring dynamics engine such as PhysBAM. Cloth simulation is a staple of PhysBAM, but hair and flesh can be simmed to great effect as well. In *Rango*, over 90 creatures were rigged for one form of dynamics pass or another. Many had several layers of cloth, hair and fur or feathers, and even flesh. Most of the 90 characters in *Rango* required cloth sims at varying levels of detail. While only a couple required a full flesh simulation, more than 15 required simulation of hair or feathers.

PhysBAM embeddings [Selle et al. 2008] are the cornerstone of both hair and flesh simulation in *Rango*. Hair and flesh are both simulated by embedding lower dimensional geometry within a simplex of higher dimension - usually a tetrahedral mesh.

A CGI character with hair or fur is usually populated with a full complement of hair only at render time in the shader. The digital artist places and models curves to serve as guides for interpolation. Our procedure then rigs these guides for simulation by procedurally generating a tetrahedral mesh of arbitrary complexity along the length of the curve. Large bundles of hair, such as those in a ponytail or braid, can have a single, large tetrahedral mesh to embed them all.

Hero level creatures with fleshy mass often require a skin and muscle simulation to properly capture the momentum and inertia of the flesh. In *Rango*, this was accomplished by embedding the skin surface in a tetrahedral mesh of artist controlled density.

The embedding system used for both hair and flesh simulate both the surrounding tetrahedral mesh and the lower dimensional embedded geometry. The tetrahedral mesh is used to provide shape and structure during simulation. The embedded geometry is usually important to remain dynamic to support accurate collisions with clothing or props. PhysBAM provides a convenient means for accomplishing this through soft bindings that transmit forces back to the higher dimensional simplex. This method is important so that forces, especially those instantiated by the artist to direct the simulation, can be integrated and solved together.

Our dynamics pipeline allows the artist to build and direct a simulation with a suite of tools that can be applied across the board for all kinds of deformables, and in some cases, even a rigid body sim. This workflow, and the suite of simulation controls, is critical to the practical aspects of production work. A digital artist who learns to set up and direct a cloth simulation can apply the same tools and skills to direct a hair simulation.

PhysBAM, being a full featured dynamics engine, makes this workflow possible. But at the end of the day it is only one component of a dynamics pipeline that must interface with a geometry pipeline that allows blending of animation and different passes of simulation. To accomplish all of the high quality simulation work in *Rango*, a large set of artist controls are required. Hair simluation in particular requires shape preserving forces [Müller et al. 2005] and position based constraints [Kačić-Alesić et al. 2003]. But a unified approach to deformable sim makes this entire suite of tools available across all elements in a shot. Useful tools [Twigg and Kačić-Alesić 2010] can be used in all kinds of sims, and an artist's knowledge on how to set up and use the tool are applicable across the board.

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