Fibre – Scaling Groom Dynamics at Framestore

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Figure 1: Lady and the Tramp, ©Walt Disney Studios 2019

ABSTRACT

Framestore has been producing award winning creature effects for over 20 years, with hair, fur and feathers being crucial elements of these creatures' visual fidelity. Simulating how these elements interact with other geometry, wind, cloth and media of varying viscosity across many hundreds of shots in a film is a time consuming and laborious process, typically requiring many refinement iterations to achieve the desired result. In this talk, we present Fibre, a stable, robust and highly parallel dynamics solver designed to help maximize production efficiency. With Fibre integrated into its proprietary fur pipeline, Framestore has been able to reduce manual post-simulation fixing by 80% and reduced the simulation time for fur and feathers by up to 50% and 80%, respectively.

CCS CONCEPTS

• **Computing methodologies** → **Physical simulation**; **Collision detection**.

KEYWORDS

VFX, simulation, fur, feathers, dynamics

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1 BACKGROUND

Framestore wrote its first dynamics hair solver for *The Golden Compass* in 2005. This had to deal with the complexities of the mid length hair of a polar bear colliding with armor plates that it was wearing. At this time, there were no suitable commercial options, and Framestore was awarded an Academy award for its work on the show. This system continued to be used and by 2016, its core Newtonian physics engine had started to become insufficient to handle the increasingly more complex grooms, geometry interactions, and shortened production schedules. A new solution was needed.

2 PRODUCTION REQUIREMENTS

While modern commercial hair solvers allow artists to very rapidly create compelling setups, significant artist input is often required to tune the setups for the unique per-shot environment interactions. Commonplace interaction situations include collisions with complex geometry, other hair or participation with other media, for example long hair being dipped in water or being dragged through mud. A system that could handle such situations, with minimal artist intervention, was required in order to fulfill the needs of large scale production. A series of requirements were formulated:

- The ability to work on a large volume of shots across multiple shows, with minimal manual post simulation fixing (so called *finalling*).
- Being able to generate consistent results across the different environments a groomed creature may appear in.
- Consistency when animation or the surrounding environment is updated, allowing for automatic re-simulation without the need for manual intervention.
- Intuitively handle complex scenarios such as grooms with multiple types of overlapping hair, complex feather systems or hair interacting with multiple mediums of varying viscosity.

- Use hardware resources intelligently, e.g. minimize cache files on disk and maximize utilization of the render farm.

No single commercial solution was deemed to be able to fulfill all these requirements, so the development of an in-house solution, named Fibre, began.

3 IMPLEMENTATION

Fibre has evolved over the past three years in close collaboration with the grooming and simulation departments at Framestore.

3.1 Data Model and Architecture

Fibre's core is based on the technique outlined in [Kugelstadt and Schoemer 2016], and is implemented using efficient parallel processing aiming at maximizing load balancing and minimizing thread synchronization. Curves to be simulated are initially divided into work bundles based on a combination of spacial proximity and per hair metrics. These work bundles become nodes in a graph where edges represent inter-bundle dependencies. A thread can work on one bundle at a time, and the order of bundle to thread allocation is determined using a graph colouring approach. Implementing this approach using atomic operations, Fibre's constraint iteration phase ends up being very close to lock-free.

Disk I/O is managed in a separate threaded subsystem to the solver, allowing simulation speed to be independent of I/O performance. Collision detection is accelerated using an in-house library that allows for very fast bounding interval hierarchy (BIH) tree construction and evolution across multiple threads, efficiently providing lists of polygon faces or curve segments that a hair may be colliding with.

3.2 Workflow and Usability

Fibre takes input from Framestore's grooming tools, providing simulation specific attributes on curves or vertices that inform Fibre about which materials should be assigned and the size and shape of the hairs that each guide hair will drive. This information allows Fibre to create volumes per guide hair that accurately represent the final render shapes and allow movement and collisions to be generated accordingly. Artists interact with Fibre via a set of Maya based user interfaces. Materials are assigned to curves using a rule based system, and per control vertex (CV) material properties can be assigned dynamically per frame based on a wide variety or metrics including the proximity to, or interaction with, geometry, fields or volumes.

3.3 Collisions and Interaction

Geometry collision testing happens on a per CV or per curve segment level. Multiple geometry contact points for a CV or segment are treated as a single constraint and are solved simultaneously. These constraints also persist between time steps, giving collisions a temporal dimension that aids resolution in situations where multiple corrections are possible. Collisions between curves are generated each time step and like geometry collisions can persist across time steps, providing temporal guidance for the relative positioning of strands, thus preventing strands passing through each other over time.

Figure 2: His Dark Materials, ©Bad Wolf/BBC/HBO 2019

4 RESULTS

Fibre has been used in production for the past three years, notably on shows such as *Lady and the Tramp*, *Detective Pikachu*, *Timmy Failure: Mistakes Were Made* and *His Dark Materials*, consisting of multiple main characters with grooms appearing across a range of different environments.

Fibre has reduced manual post-simulation fixing by 80%. Fibre's efficient use of resources has yielded an estimated time saving of 30-50%, significantly shortening the simulation setup development for complex characters. Feathers used to be simulated as cloth objects, but are now simulated as branched Fibre curves, giving 50-80% reduction in simulation times and more stable collision resolution. The efficiency of Fibre's geometry processing means that render meshes can now used as collision objects, eliminating the need for creation of proxy stand-ins.

5 CONCLUSIONS

Complex hero creature grooming and simulation is becoming increasingly more commonplace in visual effects. Shots that would previously have been approached as manual setups are now so common that in order to be cost effective, they require extensive workflow automation.

Fibre has provided Framestore with a robust simulation framework. Shot setups which previously required manual finalling intervention are now largely automatic. The strategy of building a bespoke system has resulted in a solver and a creature workflow that is deeply integrated into the production pipeline.

Fibre will continue to evolve towards an even more integrated suite of grooming and simulation tools, allowing dynamic interactions to be previewed as early as possible in the iteration process.

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