Zootopia Crowd Pipeline

Moe El-Ali† Le Tong† Josh Richards* Tuan Nguyen* Alberto Luceno Ros† Norman Moses Joseph†
Walt Disney Animation Studios

Fig. 1. Example of a Crowd scene in Zootopia

Abstract

Disney's 55th feature animated film Zootopia takes place in a modern animal metropolis. Bringing this bustling city to life required creating a universe in which moose drive cars, lions take selfies and wildebeest herds roam the sidewalks. Many different species of animals of various sizes and proportions inhabit this city and interact with each other as well as objects and vehicles in their environment, creating some unprecedented challenges for our crowd pipeline. This required us to rethink how we approach the crowd toolset. We needed to develop tools flexible enough to handle such a wide variety of cases. Building off of the work done on Big Hero 6 [Hamed et al. 2015], a modular design was constructed in which a reliable core set the foundation over which tools could be developed and abstracted, providing the framework for artists to easily construct tools and be able to build on each other's work and tackle increasingly complex tasks effectively.

Keywords: Crowds, Procedural animation, Pipeline, Modular Design.

Concepts: • **Computer graphics ~ Animation;** *Procedural animation.*

1 Introduction

With increases in show complexity, a method for procedural animation was required to accommodate the show demand.

A series of third party packages have been developed to proceduralize animation for use within an instancing pipeline but have been historically cumbersome to implement into our studio pipeline. These systems have generally been black-box and limited. A system was required that was both flexible and platform independent, providing the core foundation for future expansion and higher level tools development.

2 Skeleton Library

Skeleton Library is a platform independent rig data structure for use within a particle system. It stores joint information in an efficient hierarchy and contains a library of ways to manipulate said skeleton. Higher level toolsets can use this data structure to simulate procedural secondary animation.

†{ mohammad.el-ali | joyce.tong }@disneyanimation.com
*{ josh.richards | tuan.nguyen }@disneyanimation.com
†{ alberto.luceno.ros | norman.joseph }@disneyanimation.com

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3 Animation Consumption Process

Animation is stored as a baked forward kinematic (FK) structure to be consumed by Skeleton Library. A process was developed to extract FK animation from a complex animation rig and bake it down onto a simplified skeleton. Information pertaining to published animation is retrieved from Shotgun (A 3rd party production tracking, review, and asset management toolset).

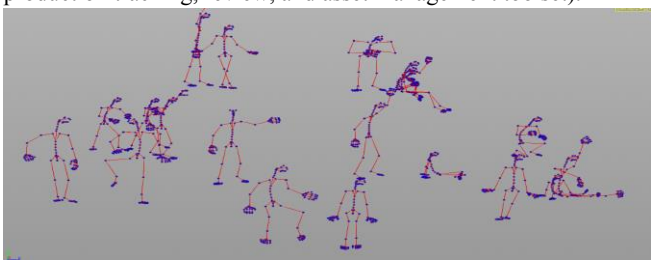

Fig. 2. *Crowd Visualization of chosen animations.*

3.1 Crowd Animation Picker

For Zootopia, we categorized all animation by tagging each animation cycle. These tags are used by the Crowd Animation Picker (CAP) to narrow down the choices of animation cycles to apply.

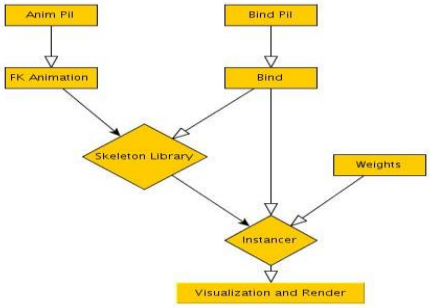

Fig. 3. *Crowd Data Pipeline.*

CAP only lists animation cycles that have been tagged for use for crowds. If any of the selections are not provided, CAP chooses randomly from all the available choices. CAP can be used to instance as many crowd particles as the artist requires.

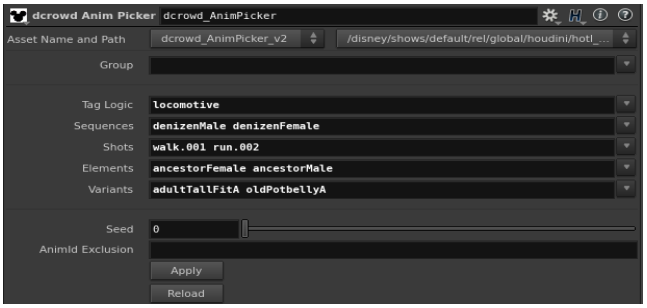

Fig. 4. *Crowd Animation Picker (CAP) Interface.*

4 Low Level Processes

For speed and robustness the essential capabilities are supported at the core (Skeleton Library).

4.1 Scaling and Mirroring

Scale is a per-instance property that scales the agent at runtime. Mirroring of an animation cycle is done in memory and on demand. The first request for a mirrored animation cycle results in a new animation cycle which is then shared across any other instances requesting the mirrored cycle.

4.2 Animation Speed

Playback rate or speed for animation cycles is supported through sub frame interpolation. We use vector blending for our interpolation which helps performance and combats problems with gimbal locking. Because Skeleton Library is frame agnostic, animation speed cannot be animated. Varying animation speed can be achieved through an animated frame offset in a sim context.

4.3 Joint offsets and Fuzzy Aim

We can offset the joint translation and rotation on a per joint basis. Fuzzy aim builds upon this and provides a mechanism for efficiently and quickly pointing a joint chain in a specific direction in space without using inverse kinematics (IK). Most commonly it is used to orient the skull joint and related spine joints, creating the impression that the character is looking in that direction. The joint chain can be of arbitrary length and rotations may be applied to each joint independently based on a heuristic.

5 Higher Level Tools

The core capabilities of the system provides a framework in which higher level tools can be authored (integrating into Houdini).

5.1 Look At

Look At tools can help artists add performance to the crowd, such as automatically acknowledging nearest neighbors or randomly gazing around the environment. The tools build upon the lower level Fuzzy Aim logic.

5.2 Follow Spline tool

This tool helps guide a crowd on any path without simulation. It can in real time adapts feet to terrain, change agents speed, look direction and scale without causing any foot slipping by adjusting the gait.

5.3 Terrain adaption

Using the IK available through SL we are able to use multiple layers of terrain adaption. We can adapt not only the foot (ankle, heel and toes) but also the root/hip to a changing terrain.

5.4 Gait Adjustment

Procedural variation of walk cycles varies things like bobbing, hip sway, leg lift, and stride length. Although SL is frame agnostic, it still has an understanding of the animation cycle. As such, filters can be run on the cycle to determine min, max, average of any joint translation or rotation. This allows us to achieve varying the aforementioned qualities without the need for a sim.

5.5 Passengers in vehicles

The passenger system is used to instance characters in the vehicles in Zootopia. It uses joint offsets and inverse kinematics (IK) constraints and even some of the higher level tools discussed above to procedurally add characters with sensible performances to the vehicles. This performance includes placing hands on the steering wheel and turning it as the vehicle turns, placing the feet appropriately as well as turning the character to look at traffic around the vehicle.

6 Placement Tools

For the large background crowds, we took advantage of tools available in Houdini to scatter the crowds on the terrain. Bounding box information for each agent is used to remove those that are within each other's bounding radius. For large background and mid ground crowds, we also developed a draw tool that allowed us to quickly draw the placement and heading of the agents**.** Finally, for agents that were very close to the camera, we needed full control not only in placement but also the finer details of the agents. Using the Crowd Placer, we can place the agent exactly where we want and also control the exact animation and look of that agent.

7 Crowd Promotion

We have a capability in our pipeline to convert a single instanced crowd particle to a fully rigged animation asset. This is useful when an animation or technical animation artist would like to update the animation of the crowd particle. Animation can then use the rigged characters to add more finely honed performance for close up characters. Since the mapping from the crowd rig to the animation rig is not one to one, the transfer process is lossy. Promotion for the technical animation department converts the single instanced crowd particle into a hero asset with a CAF file (our proprietary geometry file format that provides efficient read/write of baked mesh data) with the animation matching the crowd character's performance. The artist can then use this data to run the cloth and hair simulations.

8 Limitations and Future Work

While the framework allows us to do certain types of operations better and with more visibility in our pipeline than current software solutions of similar nature, there is still room for improvement. This underlying system is still in its, as such there is a long list of tasks on the current roadmap ahead. Such as a versatile state machine and a human IK style setup for better pose control.

9 Conclusions

A strong, robust and efficient core that is also software independent creates a framework upon which higher level tools can be built for and by the artists to accomplish a variety of challenging tasks. Ultimately tools can make use of other tools taking us from fast and efficient low level utilities to complex and comprehensive setups through several levels of abstraction. One such example might be a crowd simulation setup in which each agent takes into account the positions and actions of their neighbors and collects data about their environment to produce a performance that includes scale and character variations, control of playback speed and gait, mirroring of input animation, terrain adaptation, gazes influenced by neighbors and acknowledgment of their environment. Furthermore we never lose the flexibility to keep things simple and not over encumbered with this modular approach. As we move into new challenges we will be looking into both extending and strengthening our core capabilities as well as pushing our high level setups further in terms of the AI and the complexity of the performances that we are able to simulate.

10 References

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