Rivers of Rodents: An Animation-Centric Crowds Pipeline for *Ratatouille*

Pixar Technical Memo #07-02

David Ryu*
Pixar Animation Studios

Paul Kanyuk†
Pixar Animation Studios

One of the major technical challenges in the animated film *Ratatouille* was creating a believable rat colony. In numbers as high as a thousand, these rats participated in highly complex and coordinated behaviors ranging from chaotic swarming to gourmet cooking. Often, the colony was the featured foreground element in the shot and thus subject to the strict motion standards of our hand-animated characters. We needed a crowds animation pipeline that had the flexibility to tackle a wide variety of complex behaviors, while also delivering motion that could pass muster alongside hero animation. We chose Massive Software's Massive Prime as our simulation engine. To ensure animation quality, our Massive pipeline preserved all the nuances of the input animation and allowed the animators to easily change the simulations, while still enabling TDs to use proceduralism to create complex behaviors. To this end we deployed a number of techniques including a system for baking our deformer based character rigs into point weights for Massive, motion retargetting tools for animation cycles, and procedural methods for swarming, leaping, carrying, and climbing, among others.

Figure 1: Crowds of Rats in *Ratatouille*.

1 Massive Integration

Beyond crowds simulation, Massive has rigging and rendering capabilities. Unlike most Massive clients, however, we treated Massive as a simulation tool only, converting character rigs and animation cycles from our proprietary animation environment (marionette) into Massive, and crowds simulations from Massive back into marionette as animation data. This allowed our crowds models to use the character rigging authored in our proprietary deformer network-based rigging tool, instead of the simpler frame-weighting capabilities in Massive. We augmented our animation cycle conversion with a blind data system to deal with channels like facial animation that would be very difficult to reproduce in Massive, by encoding them as translations in proxy bones. As a result, our crowds characters had the same level of nuanced articulation as our hero characters, and allowed us to use simulated crowd rats as featured foreground actors.

To visualize our agents in Massive, we created a system to project these complicated character rigs onto a Massive-compatible smooth skinning solution, using a numerical solver to determine frame weights. Bringing the simulation back into marionette allowed animators to easily touch up the crowd after the technical team delivered the simulation. This refinement phase occurred on almost every shot and was crucial to hitting the required level of personality and quality. In practice, TDs collaborated with animators on every shot to determine the best course of action, which ran the gamut from full massive simulation with no hand-animation, to simulating only the base animation with animators layering in the rest of the action.

2 Animation Cycles

We wrote a suite of tools to simplify and optimize the creation of animation cycles, including a mirror tool to reflect animation; a transfer tool to retarget animation between different character rigs; and a pose match tool to ripple small tweaks in a base pose to a cycle or set of cycles. Our cycle creation and conversion pipeline had to work quickly and smoothly, as the diverse behaviors of our sequences required new cycles in almost every shot. In practice, there was often a series of iterations for new cycles and simulations between the TDs and animators before the desired results were achieved.

3 Procedural Behaviors

Many of our most challenging crowd shots involved hundreds of characters participating in complex interactions with their environment and each other, precluding the use of a purely state machine based solution. Instead, we favored procedural methods involving noise and curve based manipulation of animation splines and interpolation between poses. One compelling example involved creating motion for a crowd of approximately 400 rats falling through a collapsing attic, attempting to cling onto plummeting furniture, bouncing off the ground as they land, then sitting up and turning towards the camera (See attached video). The falling rats were initially distributed at randomized heights and bounced at noise driven trajectories normal to a stationary version of the falling geometry at its final pose. Momentum was approximated by filtering the translational velocities, and rotations were driven by bounce heights and noise. The joint angles were offset by a series of noise functions with relatively extreme amplitudes in order to warp our animation cycles to create the impression of frenzied flailing. The simulation was then constrained to the falling geometry in groups, some of which had their rotations counter-animated to the changing orientation of their respective props to maintain a vertical alignment. Similar techniques were used to drive the swarming and jumping behaviors seen in the film. Combining aggressive proceduralism with the flexibility of hand-animation, our animator-centric approach gave us the tools we needed to create some of the most complex yet nuanced crowd behaviors in feature animation to date.

Figure 2: Crowds of Rats in *Ratatouille*.

*e-mail: ryu@pixar.com
†e-mail: pkanyuk@pixar.com