

# From Armadillo to Zebra: Creating the Diverse Characters and World of Zootopia

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**Figure 1:** View of the city plaza environment from Zootopia with a crowd of various species. ©Disney Enterprises, Inc.

## Abstract

The world of Zootopia is a vast, multi-scale, multi-climate city that integrates the biomes of tundra, desert, rainforest, and grasslands. It is also a place where humans never existed and animals evolved to become anthropomorphic, clothed, city-dwellers. Walt Disney Animation Studios was challenged to push the artistic boundaries of all aspects of our production process to create vastly different environments filled with unique and detailed characters. The scale difference between animals, from giraffe to mouse, required us to design and build a world that could be convincingly inhabited by characters and vegetation of all shapes and sizes. Depicting thousands of furred and clothed animals moving through landscapes filled with grass and trees necessitated innovative solutions to efficiently represent the scope of detail required to create believable scenes. Our presentation will touch on both the artistic and technical methods we developed to create, animate, and render the world and characters of Zootopia.

**Keywords:** environments, fur, vegetation, procedural modeling and animation, production pipeline

**Concepts:** •Computing methodologies → Rendering; Shape modeling; Animation;

## 1 A Diverse Range of Environments

Zootopia's environments presented challenges in both the sheer scale and diversity of their climates. With four unique biomes all represented within a single city, we needed to build and depict each of them together while allowing them to feel distinct. Research on climates lead us to develop a new sun and sky shader for use

in lighting outdoor shots and to make more extensive use of atmospheric in all of our environments. Volumetrics helped convey both the arid heat of a desert climate and the fog and humidity of a rainforest.

Our vegetation pipeline was extended to support the scope and diversity of plants throughout the city, from the miniature shrubs of Little Rodentia to the towering trees of the Rainforest District, where some species reached hundreds of feet high. This included updates to our in-house tree modeling tools to allow for more art-directable procedural variation while instancing geometry where possible for render efficiency. An additional artistic goal we set early on was to allow for animated wind on branches and leaves without sacrificing this efficiency in order to make the trees and forests feel alive.

The challenge of scale extended to our characters and city. The largest animal in the film was ninety-five times taller than the smallest, so our world needed to support these extremes and the entire range between them. All buildings, transportation, and props were designed, built, and laid out with the consideration that animals of many scales would populate each environment. The characters themselves required us to add enough detail in their fur, clothing, and textures to support seeing them in close-ups, from only the leg down or as they towered over others. This detail had to be scaled back efficiently to support these same characters in wide shots with hundreds of others in large crowds. The cinematography and staging had to address these scale differences during the interactions between characters.

## 2 Understanding the Aesthetics of Fur

We wanted to push artistic boundaries in all aspects of our depiction of anthropomorphic animals, creating large numbers of characters that were highly detailed while remaining appealing and stylized.

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This required not only that they had believable, natural fur, but also to wear convincing human-like clothing while retaining their animal-like qualities. We began with research, from the macro-level behavior and movement of various animals in their natural environments, down to the micro-level structure and motion of their fur.

Based on this research, we wrote a new fur shader within the framework of our global illumination renderer that allowed artists to describe the diverse range of mammal species using principled controls. Our in-house fur tools were augmented to enable artist-friendly brushes to define the length, orientation, and shaping of the groom in an intuitive, controllable way. To allow animators to visualize the full fur silhouette of the characters during interactive work, we implemented a technique to cache and visualize part or all of the grooms as a character is posed and moved. The system provides tuneable controls to balance performance with visual quality. This decreased artist iterations by providing real time feedback of the fur without needing to rely on a full render.

We developed additional tools to create, finesse and manage highly-detailed fur motion, down to the strand level when desired. This included everything from collision interactions, procedural bending and flattening, and cutting or culling, to complex simulated secondary motion that could be input from both in-house and third party tools. Automating the setup of these techniques allowed many characters to work "out-of-the-box" for simple cleanup operations, reducing artist time for more basic fur interaction results while freeing them to work with the same intuitive setups for more complex manipulation where needed.

Finally, we optimized the way each character's fur was built based on the render camera so that they would process in about the same time as a typical non-furry character. These controls were designed to preserve the artistic intention of the groom at a distance while vastly reducing the memory and time required to depict the full look. Along with a baking system to reduce computation time for background character grooms, this enabled us to render scenes with crowds containing thousands of furry characters.

### 3 Results

The broad range of challenges inherent to the scope of environments and characters of Walt Disney Animation's "Zootopia" motivated a wealth of investigation into the diverse nature of the climates, vegetation, and animals present in the film. This led us to discover innovative solutions to create and manage the complexity of this rich world and its inhabitants, extending the capabilities of our studio. Zootopia is a multi-faceted, diverse anthropomorphic metropolis, grounded in observation and research, designed and augmented by artistic vision, and realized with more life-like detail than anything we have been capable of depicting on-screen before.