STUART LITTLE 2: Let the Feathers Fly

By: Debra Kaufman

Based on interviews with Eric Armstrong, Jay Banks, Virginia Bowman, Rob Bredow, Aaron Campbell, Jerome Chen, Henry Darnell, Rob Engle, Kevin Hudson, Loree Perrett, Jay Redd, Pete Travers and Bob Winter

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Course Outline

As we went to press on this publication, production on “Stuart Little 2” was on-going. Presentation slides are available for download at http://www.imageworks.com/StuartLittle2CourseNotes/index.html.

Module 1: Show Overview
Presenters: Jerome Chen and Jay Redd

Introduction:
Scope of the show, number of shots, time frame
New York as a backdrop, how location shooting changed everything
New requirements both technically and artistically
Visual and technical comparison of “Stuart Little” and “Stuart Little 2”
Review of fur and cloth techniques from the first film

Module 2: Character Design and Animation
Presenters: Eric Armstrong and Jay Redd

Character Design:
Reality vs Fantasy; Bird Research; making “Margalo” an appealing heroine; making “Falcon” an intimidating villain; changes in Stuart’s design; updating technology

Character Animation:
Difference between all CG films vs live-action/CV integration; changes in how characters were set-up
Cat Animation
2D facial animation vs 3D animation; facial muscle system for cats/pros and cons
Module 3: Feathers and Digital Environments
Presenters: Rob Bredow and Rob Engle

CG Feathers:
Defining a feather; modeling; grooming; populating the bird with feathers; handling feather interpenetration; unique requirements for each character (gold finch: the “cute” factor; Falcon: patterning on feathers)

CG Clothing:
Subdivision surfaces; more complicated costumes; improvements in look; limitations on what Stuart could do with cloth removed

CG Environments and Props:
CG buildings; CG environments; CG vehicles and props

Module 4: Putting It All Together
Presenters: Rob Bredow, Rob Engle and Bob Peitzman

Compositing
What makes a shot “real”? Specialized techniques for integrating characters and props

Digital Film Finishing
The traditional film finish process; a digital film finish, comparison of results

Production Pipeline Optimization
Speeding up fur renders; techniques to improve interactivity; moving the studio to Linux

A Day in the Life of “Stuart Little 2”
Presenter Biographies

**Eric Armstrong**  
*Animation Director*  
*Sony Pictures Imageworks*

Eric Armstrong joined Sony Pictures Imageworks as animation director in November 1995. Most recently, he served as animation supervisor on “Harry Potter and the Sorcerer’s Stone” where he oversaw the animation of the Troll, Fluffy, the three-headed dog and the Centaur. He has also supervised work on “Stuart Little” and “Anaconda” and was animation director on the highly anticipated sequel “Stuart Little 2.”

In 1991, Armstrong joined Industrial Light and Magic as computer animator, working on a variety of television commercials, including spots for Heinz, Pepsi, and Toyota Celica. He was quickly promoted to ILM’s feature film division, where he worked as animator, animation supervisor and animation director for the feature films “Star Trek VI,” “Jurassic Park,” “The Flintstones,” “Casper” and “Jumanji.” Armstrong has earned a reputation as one of the finest talents in the field, having helped develop technology that generated lifelike dinosaur movements in “Jurassic Park.”

One of Armstrong’s first jobs out of college was at Toronto’s Nelvana Productions, where he was a cel animator for a number of Canadian television series. Relocating to Chicago in 1988, Armstrong worked at Post Effects, where he began working in computer graphics while animating for television commercials. His next assignment brought him back to Toronto, where was the Creative Director for Side Effects, a computer-based graphics company.

Armstrong, a graduate of Toronto’s Sheridan College, was raised in Brantford, Ontario, Canada.

**Rob Bredow**  
*Senior Computer Graphics Supervisor*  
*Sony Pictures Imageworks*

Rob Bredow is a CG Supervisor at Sony Pictures Imageworks where he recently wrapped “Stuart Little 2.” While at Sony, Rob has been involved in creating many of the complex visual effects featured in both “Castaway” and the first “Stuart Little” film.

Rob’s other credits include Visual Effects Supervisor on the feature film “Megiddo” where he supervised both the practical and the digital requirements for its 250+ visual effects shots. He also served as Director of Research and Development at VisionArt, where he created visual effects for “Independence Day,” “Godzilla,” “Star Trek” and others. His experience at VisionArt included building the industry’s first real-time optical motion capture system and designing VisionArt’s proprietary particle and rendering system affectionately named Sparky.

Rob is an acknowledged expert in the field of effects animation, shading and rendering and has presented at several conferences, including the Advanced RenderMan® course at SIGGRAPH 2000.
Jerome Chen  
Visual Effects Supervisor  
Sony Pictures Imageworks

Jerome Chen joined Sony Pictures Imageworks shortly after its inception in 1992 and worked his way up through the production ranks as a digital artist, senior animator, computer graphics supervisor, digital effects supervisor and now visual effects supervisor. He is an acknowledged expert in the technique of integrating digital imagery with live action, especially in the area of photorealistic effects. His film credits include “Stuart Little,” “Godzilla,” “Contact,” “James and the Giant Peach,” “The Ghost and the Darkness” and “In the Line of Fire.”

With “Stuart Little,” Chen earned his first Academy Award nomination for the ground breaking visual effects in the creation of the title character, Stuart the mouse. Chen was instrumental in the development and advancement of digital imagery techniques including innovations in digital lighting, compositing, fur and cloth.

Chen's peers have repeatedly recognized his contributions to visual effects. He is a two-time Monitor Award winner in the category of Best Electronic Effects in a Theatrical Release for his work on “Stuart Little” and “Contact,” and also received Monitor Award nominations for “Godzilla” and “James and the Giant Peach.” Additionally, Chen was honored with a 1998 ANNIE Award nomination for Best Special Effects Animation in a Feature Film for his effects animation work on “Godzilla.” He has also spoken internationally on the topics of digital character creation and imagery techniques.

Currently, Chen is visual effects supervisor on the highly anticipate sequel “Stuart Little 2.” “This film is another great opportunity for new innovations in the area of digital main characters in a live action environment,” says Chen. The sequel to the 1999 hit film introduces two birds, Margalo and Falcon, to the world of Stuart Little, requiring Chen and his team to tackle the challenges of believable integration and performance of feathered characters.

Chen is optimistic about where digitally created character filmmaking is headed at Imageworks. “We’ve taken advantage of our opportunities on “Stuart Little” and “Hollow Man” to advance our character creation abilities,” notes Chen. “The more we learn, the more we can draw the audience into stories involving new forms of characters.”
Rob Engle  
Senior Computer Graphics Supervisor  
Sony Pictures Imageworks

After earning his bachelor’s degree in Electrical Engineering and Computer Science from the University of Colorado, Rob Engle worked for the Hewlett Packard Company developing IC Computer Aided Design software used to create many of the company's computer and test equipment products.

In 1995 he attended Stanford University to earn his masters degree in Computer Science and while there, interned in the software department at Industrial Light & Magic. The experience convinced Rob he could marry his long-standing interest in the technical side of theater and concert sound with the burgeoning field of digital effects in the entertainment business.

He found the perfect niche for his talents when he joined Sony Pictures Imageworks in 1996. Rob first worked as lead software engineer on the company's in house RenderMan® interface, but quickly moved into more direct production roles including lead production software engineer on “Contact” and lighting pipeline lead on “Godzilla.” He developed the lighting pipeline and initial R&D for the tools used to create Stuart’s fur in the Academy Award nominated “Stuart Little.” As a Computer Graphics Supervisor, Rob led the feather R&D and look development teams responsible for creating Stuart’s avian co-stars in “Stuart Little 2.”

For SIGGRAPH 2001, Rob served as the pre-show director for the Electronic Theater and, though he created the “TEAPOT” trailer for the pre-show, he has never met Sigourney Weaver in person.

Bob Peitzman  
Senior Compositor  
Sony Pictures Imageworks

Bob Peitzman joined Sony Pictures Imageworks in February 1996 and got his start as a junior compositor on "The Ghost and the Darkness." Since then, he has helped to create numerous shots for 10+ movies at Imageworks.

A graduate of the Radio/Television/Film program at Cal State Long Beach, he was an instructor of compositing software at the school’s extension program. Bob then teamed with a traditional film company to assist with their transition to CGI for use in film titles and trailers. Building on this experience, he moved to Imageworks. Blending both his design and programming skills has proven invaluable in solving some of the more technical shots for films like "Starship Troopers" where mammoth battleships were destroyed in great detail. He also orchestrated complex shots for "Hollow Man," "Cast Away," "Godzilla" and others. He helped with early look development on "Spiderman" and "Stuart Little." Bob also served as technical director and senior compositor for both"Stuart Little" and "Stuart Little 2."

Bob’s other credits include Compositing Supervisor for Kleiser-Walczak on last year’s "The One" starring Jet Li.
Jay K. Redd  
Digital Effects Supervisor  
Sony Pictures Imageworks

Jay Redd joined Sony Pictures Imageworks in August 1996 to work on the Robert Zemeckis film “Contact.” As an amateur astronomer with a longstanding interest in the project, he was the perfect person to create the film’s opening shot, a 4710 frame, 3 minute and 19 second journey from the earth to the end of the known universe. The open was the first digital animation to be nominated for an Annie Award.

He next helped to create the title character for “Stuart Little.” “Our goal was not to create a realistic character, but a real character,” Jay said. “We wanted Stuart to seem so real that the audience would believe they could go take an actual picture of him. To do this we had to create fur, cloth and skin. This was the first time the lead character in a film was fully CG.” As a result of this effort, Stuart received an Academy Award nomination for digital character.

Jay was Digital Effects Supervisor on the highly-anticipated sequel “Stuart Little 2.” The film not only reprises the title character, but adds two photo real bird characters. “Birds present a much more difficult task than Stuart because of their feathers and complex movement,” Jay said. “The feathers have to slide past each other and not through each other. And it’s a challenge to have a bird be a ‘cute’ character and still be realistic.” However, Jay knew the talent at Imageworks was up to the task. “Everyone on the team knows the challenge is to make these birds be as real as Stuart. But just as Stuart was real, Imageworks will once again break new ground with these new birds.”

Prior to Jay's arrival at Imageworks, he spent four years at Rhythm & Hues where he worked as a CG supervisor on numerous commercials, the Seafari theme park ride and feature films as the Academy Award-winning “Babe” and “Waterworld.” Jay began his visual effects career in his native Salt Lake City where he worked in a post-production facility doing digital photographic retouching, typography and graphic design. In 1993, he decided to continue his career in computer graphics in Los Angeles. He ventured to California for the SIGGRAPH 93 conference where his flair for photography led to his first job at Rhythm & Hues as a Technical Lighting Director.

Jay has also traveled in the US and around the world to speak and lecture at UCLA, London Effects and Animation Festival, FMX, Australian Effects and Animation Festival, SIGGRAPH and many others. Most recently Jay and fellow Imageworks supervisor Jim Berney organized and presented a full day course on the making of “Stuart Little,” to a sell-out crowd of 2400 people at SIGGRAPH 2000 in New Orleans.

Jay, who was born and raised in Utah, studied photography, music and Japanese at the University of Utah. His study of photography and photographic lighting techniques continues to play a significant role in his career. He has also worked with computers since the age of twelve.
STUART LITTLE 2: Let the Feathers Fly

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STUART LITTLE 2: Let the Feathers Fly

Introduction
and Overview
When it debuted three years ago, “Stuart Little” charmed audiences and wowed critics around the world, with its tale of the doughty mouse, his loving adoptive parents, the Littles, and the villainous Snowbell. From the first weekend of the film’s release and enthusiastic reception from audiences and critics, the plan was hatched to do a sequel. Sequels are notoriously difficult, often criticized as being pallid imitations of their more successful older brothers.

“Stuart Little 2” not only dispels that criticism but blazes a path in the new genre of the hybrid CG/live-action film with its three digital main characters paired with a very real Manhattan. To plot “Stuart Little 2,” once again, the writers went back to the original, beloved E.B. White book. As “Stuart Little 2” opens, size is starting to make a difference in Stuart’s relationship with brother George. Stuart is too little to play soccer, and George is making friends his own size, while his mother is a tad over-protective of her pint-sized mouse-son. The lonely Stuart meets Margalo, a bird who literally falls out of the sky and lands in his car. Her relationship with Stuart and his loving family changes her life…until a threat from a villainous Falcon forces Margalo to make some tough decisions.

Directed again by Rob Minkoff, and shot by cinematographer Steven Poster, ASC, “Stuart Little 2” involved a group of familiar faces from Imageworks. Jerome Chen, who was co-visual effects supervisor of the first “Stuart Little,” was the sole visual effects supervisor on this film; Jay Redd, who was a CG supervisor on “Stuart Little” was digital effects supervisor on SL2 (“Stuart Little 2”). Eric Armstrong, who was a lead animator on the first “Stuart Little,” teamed up with Tony Bancroft as animation directors on SL2.
The scope of this movie can't be measured by the number of shots, which was 760 compared to 640 in the first “Stuart Little.” “Stuart Little 2” was much more difficult to accomplish, for many reasons. In approaching the first “Stuart Little,” Imageworks needed to answer the question of whether they could create a digital mouse. That entailed creating believable fur and cloth as well as creating a robust character animation pipeline. “Stuart Little 2” ups the ante considerably. The new film stars not one but three main characters who are completely computer-generated. Two of them are birds, which required the creation of feathers, the design of characters that straddled the line between reality and fantasy, and flying — all major challenges. Lastly, unlike the first film, which took place largely indoors, “Stuart Little 2” is a true action-adventure film. The movie is constantly out on the streets, parks, buildings of a very real New York City, challenging Imageworks to create a true integration of CGI and real elements.

“Stuart Little 2” ended up being 80 percent animated. Unlike an all-CG film, which creates and maintains its own world, SL2 had to create believable digital characters and environments – but to believably integrate them with very real characters and environments. In the end, “Stuart Little 2” brings the viewer even deeper into the believable world of the always-charming Stuart and introduces him to the equally believable and compelling Margalo and Falcon. As they draw us into their world, their characters and acting, their expressions of emotions, become our reality. We forget that they exist only in the computer.
A Visual and Technical Comparison of SL and SL2

In “Stuart Little 2,” Stuart himself will be instantly recognizable to anyone who saw the first film. Nonetheless, there are significant visual and technical differences between the two films. “Stuart Little” was a fairy tale and very much a “backlot” movie, shot completely on a set. In contrast, “Stuart Little 2” has a more realistic feel to it since so much of it was shot in the outdoors with genuine outdoor lighting. Though “Stuart Little 2” is still a fable, it does take place outside in a real city, New York, which is edgy and raw, making it a mixture of fairy tale and reality. Bringing the digital characters into a real environment makes them seem more real. Perhaps because this production was shot outdoors, the filmmakers had a constant urge in this movie to get a little edgier, and they constantly pulled themselves back. The result is that “Stuart Little” teaches good values and is a good adventure story without being violent.

In the first movie, Imageworks artists had the human performances to anchor the performance of the CG character. In this one, they pushed the limit of extracting a performance from CG characters in a live-action environment. SL2 follows the CG characters on an adventure that takes them out into the very real streets and skies of New York. In doing so, it still holds onto this element of humanity. We still have to be completely engaged by them and fear for their safety when menaced by the villain.

In “Stuart Little 2,” the camera gets closer to the digital characters than most directors or photographers get to humans. There are a few hundred super-close-ups of these characters, which weren’t in the first “Stuart Little.” “Stuart Little 2” also had a different director of photography, Steven Poster ASC. Poster’s camera is moving all the time, which required Imageworks to improve its matchmoving technology.

—Jerome Chen

Technically, this film is much more complicated and complex as far as development, interaction of the characters and the degree of interaction between the CG elements and the live-action world. Looking at the two pictures side by side, the first “Stuart Little” is an exploration of creating a CG character and placing him in a live-action movie, whereas “Stuart Little 2” is about Stuart’s relationship with another CG character.
“Stuart Little 2” has a definite difference in its color palette. Director Minkoff has a feature animation background where saturated colors are the norm. That shows up in SL2. Some things had to be retained, such as the décor and palette of the Little house. But the colors are even more storybook on this one than the first film. There are lots of reds, oranges and yellows with Stuart and Margalo. Even the extras in Central Park wear a lot of the same colors. (One color you won’t see is purple, which Minkoff doesn’t like much.) The film’s message is about finding the silver lining in every situation and the joy of finding a friend. It’s about happiness, and these colors create a fantasy world that everyone would love to live in.

Also visually different in “Stuart Little 2” is that Imageworks created an entirely digital location, the Pishkin Building where Falcon lives. They shot three locations in New York and integrated it into those locations, making it feel like it’s one place. That was certainly a challenge to make a building that doesn’t exist feel like it’s weathered and lives in the same architectural style as the other, real buildings in New York.

There’s also a lot more action in “Stuart Little 2.” Yes, the first “Stuart Little” had its chase sequences and Stuart did drive an automobile. This time, however, they’ve added a skateboard and an airplane as well as a car – all vehicles that the characters put to good use as they careen through and over Manhattan.
A Quick Review of Fur and Cloth/The First “Stuart Little”

One of the factors that made the immense challenge of SL2 possible is that Imageworks could rely on the R&D (research and development) for the first “Stuart Little.” To even consider producing the first film, they had to know that they could create believable fur for Stuart and simulate cloth for his costumes, two tricky tasks that, at the time, had been beyond the scope of existing software.

Stuart’s fur was essential in making him both believable and cute. Important attributes included the scale and quantity of individual hairs as well as how they moved and interacted with the skin. The fur had to have specular surface that would reflect environmental lighting and give Stuart’s fur sheen. The fur also needed to transmit light, to give his flesh the “glow” of living tissue. The fur also had to be affected by the environment including wind and water and displaced by objects and clothing.

The fur team, led by then-CG supervisor Jay Redd, first detailed a list of requirements for Stuart’s fur and then went through a rigorous research period. Pixar’s RenderMan® had just added a new set of primitives that made it easy to draw an individual hair, and Imageworks’ fur team created a pipeline that made it easy to generate a large number of hairs efficiently. Most important was designing a fur pipeline to leave the largest creation of data – the hairs – until the last possible step.
The R&D team worked on creating wet and partly-wet, clumpy fur for a key sequence in which Stuart escapes from a storm drain. Finally, lighting was key to integrating Stuart into the scenes. Since he’s the leading man, he was lit and treated just like the film’s live-action movie stars, requiring the development of a new diffuse lighting model that was intuitive for the TDs to light with. The key ingredient to Stuart’s “magic” lighting was his rim light and silver lining, which was used in most every scene.

Cloth also had to look and move as realistically as possible for Stuart to be believable. With as much attention to detail as a real costume, Stuart’s wardrobe was designed by a costume designer and fitted by a tailor – all in the computer. Specific details included collars, piping, buttons, and fabric weave and grain. The cloth had to fall properly on his body and also react to the same environmental factors as the fur. The pipeline also had to be able to support 13 costumes for three characters.

Alias/Wavefront was in the alpha stage of developing a new cloth plug-in for Maya, and “Stuart Little” gave the cloth team the opportunity to use this new plug-in and build tools around it. One such important tool was Davey Fashion Designer to stitch together the pattern parts, like a real costume. In addition to animating the costumes as the character wearing it moved, they also had to add a wind effect in post. Wrinkles, creases and seams helped to bring all the digital costumes to life.
New Requirements

One of the appealing factors of creating a sequel to “Stuart Little” was the idea that all the thousands of hours of R&D that went into developing Stuart could be put to good use on a sequel, making it easier to accomplish. It was agreed going into preproduction that the old Stuart “as is” would be used, to save money. But, like many a well-laid plan, it didn’t exactly turn out that way.

Three years after starting the first film, a lot had changed: the technology, the pipeline, even some basic software they were using. Innovations were made on subsequent films that made animation, lighting, and compositing easier. In the first movie, Stuart never took any of his clothes off; he was built mainly to support only clothing, not to look perfectly like a body. In this film, there was a scene where Minkoff wanted Stuart to take his shirt off. That in itself required going back in and modeling an actual presentable anatomy to him. His forearms, wrists and shoulders had to be redesigned and refit, in order not to look too freakish.

In the end, while Stuart wasn’t built completely from scratch, his sculptural forms were modified heavily. In the process, the opportunity was taken to move points around and correct face shapes, based on shortcomings identified in his previous film performance.

In SL2, Stuart is a lot more introspective. One of the ways to portray what he’s thinking is to give Stuart the ability to convey the direction of his line of sight. Stuart’s eyes are pure black orbs which, while cute, wreaks havoc with eye direction, because of the lack of iris and pupil. In the first movie, he conveys line of sight mostly by where he points his nose. They wanted to be able to let Stuart look out the corner of his eye.
Rebuilding Stuart didn’t take as long as it took to build him the first time, mostly because the design process did not have to be repeated, which had been so time-consuming for the first film. Though his looks were defined, some of his new movements and performance varieties were not. Of course, he couldn’t look different than the last film. Things that worked simply couldn’t be lost.

Because two birds are among its main characters, “Stuart Little 2” also features flying – and lots of it. Over 40 digital shots involved flying off the edge of buildings, Central Park, and streets. All of this required a tremendous amount of careful planning, rigging and aerial photography.

The production pipeline was updated thoroughly, making it smoother and more accurate and efficient than on the first film. There were certain tools that were built for the first film that were good as a foundation. But with the new requirements, such as twice as many costumes to build in a shorter amount of time, these tools needed to be improved. Some of the top costumers from “Stuart Little” got together and came up with a list of what they wanted. They paired up with the software engineers, who started honing in on changes to automate things that were previously manual. Exploration of easier and more accurate tools to light Stuart in different environments was also started.
Previsualization

As soon as there was a design for the set, they took a blueprint and actually built a model of it in the computer. That way, when they walked on set, they would know exactly what they had to do to get a certain angle or a certain view, whether it was breaking out a wall or moving the camera back. They were able to plan almost completely for the actual shoot.

In the first “Stuart Little,” they previsualized about 50 of the trickier shots, including the boat race and the cat chase sequences. This time around, the director wanted to be able to visualize all the possibilities before they started shooting, by previsualizing any and all scenes that involved the digital characters. In other words, almost the entire movie!

If you have two actors, you can take them into a room to rehearse and block out the scene. You can’t do that if your lead characters are digital, so they used previsualization to block out scenes and “rehearse” the characters and cameras. They’d start out a first pass with a storyboard artist. Another reason for previsualization is that there are motion control shots where the camera is moving six inches, very precisely. Previsualization not only helped them figure out the key information to give the motion control operator but to block the scene and come up with interesting camera angles. It was also extensively for the dogfight sequence, in order to figure out the aerial trajectories.

In the end, previsualization lead James Battersby and his team probably produced 500 or 600 shots, using Alias/Wavefront Maya. They created a proprietary virtual camera that accurately reconstructed the actual focal characteristics of a film lens. The virtual camera was tricked out to provide them with readouts revealing important factors such as focal length, lens positions and other things to help them relate their previsualization to the physical world.
Location, Location, Location

The CG/live-action hybrid film can be much harder to do in many respects than an all-CG film. Matching the CG to a live-action world — the look of the actors and the sets — is an extra component that can be immensely difficult. But the impact of seeing the characters inside a live-action environment makes it that much more engaging.

SL2 contains many more expansive environments, situations, bookended with dynamic chase sequences. There are about 40 purely CG shots in this movie, at least twice as many as in the first film. And, in any given shot, 70 percent of the frame is digital because of the characters. SL2 contains at least six times as many close-ups as in the first film, putting yet more demands on the realism required for the digital characters to hold up.

In the first movie, everything was shot on a set. No one ever even went to New York City, although there are shots of New York. Set building and matte paintings can be wonderful tools to replace location shooting. However, this time, with first unit, second unit, a visual effects unit and an aerial effects unit, New York City played a major role in SL2. It was a phenomenal experience for all, shooting in New York for two and a half months in the Spring of 2001. The weather ranged on any given day from 85 degrees and gorgeous, to 45 and rainy. Most importantly, cooperation from the city of New York was tremendous and the people of New York were gracious.
STUART LITTLE 2: Let the Feathers Fly

Stuart goes through so many environments, the crew and artists had to basically be ready to do anything. He flies off the edge of a building; he flies a plane through the house and out the front door into a park, where he goes under a canopy of trees. Margalo plays in a water-filled birdbath. Stuart and Margalo drive in the middle of New York streets, into a tunnel, under trucks, and dodging through people all while being chased by Falcon. Stuart flies a plane off a building, chasing Falcon, chasing Margalo.

This movie was also much more physically challenging because Stuart interacted with so much of the physical world: Flying, being chased through the streets, falling off buildings. For example, in one scene, all the script said was “Stuart and Falcon have a dogfight.” Director Minkoff wanted them to chase each other through streets, through Grand Central Station and through the park. That one little sentence generated 20 weeks of storyboarding and previsualization and resulted in about 100 shots.

Storyboard sequence order from top left to right

1  2  3

4  5  6
Not everything in New York City is real, however. Originally, Falcon was supposed to live in the Chrysler Building, New York’s art deco landmark, but it was decided that it was too obvious a location. The villain needed his own lair and, on the director’s prompting, a new building was invented. The “Pishkin Building” was the result of extensive scouting throughout New York to decide what it should look like and where it should be placed. The New York Historical Society off Central Park was chosen as the base of the soon-to-be-built digital building. Weeks of subsequent photography, design sketches, and sculpts resulted in a completely digital version of the building.

To simulate Falcon soaring off his lair in the Pishkin building, they devised complex rigging to shoot background plates. Smaller versions of these rigs were done in the first movie, tracking Stuart’s car 40 or 50 feet, but this technique was dramatically extended in SL2.
Aerial Effects Photography

Stuart’s greatest adventure to date is his aerial duel with the Falcon. The challenge of realizing the flying sequences was as difficult in some respects as creating the feather technology. In this case, the challenge was not virtual but rather the physical demands of obtaining the photography for background plates. Stuart’s confrontation with Falcon takes them from ground level to several thousand feet into the air above Central Park.

Several methods of aerial photography, from full-size helicopter camera platforms to small remote helicopter units were explored. Various restrictions eliminated almost all options and compelled them to devise a method that suspended a camera from a high tensile-strength rope and allowed them to ‘fly’ the camera along a particular path.

They conscripted Earl Wiggins to aid their efforts in achieving the dynamic flying footage of Stuart’s flight over Central Park. Wiggins’ expertise was getting cameras and production crews into impossible environments. In this case, they wanted to be able to dive off a skyscraper hundreds of feet above the ground and plummet towards the street, pulling up at the last moment to skip over treetops. Wiggins’ entertained all of Imageworks’ ambitions and devised incredible feats of engineering to help them photograph the aerial background plates.

They created a specific flight path for the flying action, tracing a route from the Pishkin Building, across Central Park West, into Central Park proper through Literary Walk and finally over Bethesda Fountain. This map was a key visual tool for all the photography units during their planning of the shoot in New York City.
It required months of conceptualization in the form of storyboards and 3D previsualization for them to determine the action and pacing of the aerial chase sequences. They broke the flying action apart into three levels: ground level, treetop level and high altitude. This helped determine the techniques for achieving the shots. Photography for ground level action utilized a combination of a Steadicam on an All-Terrain Vehicle or a rope-suspended flying camera rigged at head level.

The treetop level action was another variant of the suspended flying camera rigged by Earl Wiggins. The rigging for the long treetop shots were enormous efforts involving two hundred-foot construction cranes supporting the high-tensile ropes. The ropes themselves were wound around precision motion-controlled drums, which controlled the acceleration and speed of the camera flying through space.

The high altitude flight shots required no effort from the photography units; these shots would be completely digital, combining CG Margalo and Stuart with multi-layer matte paintings for the clouds and skies.
Planes, Trains and Automobiles

No, there are no trains in SL2, but there is a skateboard, an automobile, a parachute, and a plane that goes from brand-new to salvaged. Creating a digital model airplane and toy car that looked believable, and then fitting them into the physical production was a new area of exploration.

The increase in the number of vehicles in SL2 meant a tremendous leap in the number and level of very dynamic interaction between props and Stuart. Not only did the characters and the vehicles have to be created, but they also had to be seamlessly integrated into the live-action environment. For example, when the car skids, that required the creation of a dust cloud, when the plane breaks, pieces fall off, when the birds get jostled, feathers fly.

The plane is actually almost a whole other character. The first time we see the plane, it crashes in Central Park and is wrecked and thrown away. Later, Stuart gets stranded on a garbage barge after being left for dead by the villain, and finds the wreckage of his plane. He puts it back together in a whole new form with tape, paper clips, wire and yoyos and flies it back into the city to rescue Margalo. The plane had to look real as it flies through the city. It's always about to fall apart, with pieces flying off of it, so there's always another level of integration that had to be incorporated.
Character Design and Animation
Creating the first “Stuart Little” was an adventure. Stuart had to be a believable mouse and an actor capable of expression. Imageworks had to create fur and realistic costumes. This time around, they not only had Stuart to worry about but two new characters from an entirely different species! Feathers, beaks, wings and claws became a new world of groundbreaking design and animation.

**Integrating Digital Characters into a Real World**

An all-CG movie is tremendously challenging, but has the freedom of being its own world. When that world is stylized, it allows the opportunity for the animation to also be stylized. Integrating digital characters into live action plates has its own, very specific challenges. The viewer is constantly comparing the digital characters to the real actors, often in the same scene or even interacting with one another. There is a reality, a believability to an actor and what they do and how they do it and the digital characters have to try and live within those same parameters. They had to be very conscious of not going too cartoony because it stands out too much. The trick was to reach a balanced point where the reality and believability are there, but the performance is what they needed and wanted it to be. If the character is not appealing and entertaining, there’s really no point in creating him — digitally or any other way.

A lot of thought went into the design, and they always tried to push to keep the birds more to a real bird nature, feel and look. And even though Margalo certainly doesn’t look like a real bird, at least you buy into that she comes from the real world.
Anthropomorphism: Representation or conception of God with human attributes; also, ascription of human characteristics to things not human.
—Webster’s Dictionary

Birds have virtually no human-like qualities. In fact, if you look at them close-up, they’re pretty scary. Their feet are claw like and reptilian. Their eyes are on either side of their face and their nostrils are right in the center. Their mouths are bony, cartilage-like protrusions. They don’t have any teeth. Their tongues look like a finger. Their eyes are perfectly circular, and they have a third-eye-like membrane. Even their knees appear to bend the wrong way.

To take what are essentially prehistoric, alien-like creatures and turn them into characters that were believably birdlike but also not terrifying was a unique challenge.
The Cute Factor

When Imageworks designed Stuart for the first movie, they struggled to find the “cute factor” that would enable them to turn a realistic rodent into a lovable main character. At the time, they looked up the definition for “cute” in the dictionary, and compiled a list of what people think are cute...puppies, bunny rabbits, baby chicks and so on. They started deconstructing what all of these “cute” beings had in common and they found that cute characters all have disproportionate features. A puppy's eyes are big, its paws and ears are large. That's why a mouse, even if it's cute because it's small, can be scary: it has beady little eyes and a pointy nose. But if they enlarged the features, making big ears, big eyes, big paws, hands, big tails, suddenly the cuteness factor really starts to happen.

Though it can be cheated in traditional animation, to make a three-dimensional, physical Margalo who was cute and yet still a bird was tougher. First of all, they had to consider that, with Margalo, they were pairing up Stuart with something that could actually kill him in the real world. A bird would take out a mouse in a second. From the beginning, because of their work on SL, they knew Margalo didn’t have to be a real bird. Based on their work in designing Stuart, they instinctively knew that her eyes had to be bigger than those of a real bird. They also learned what not to do from their work designing Stuart. If they translated their conceptual images directly into 3D computer models, it would short-circuit the design process and not allow the freedom to truly explore the 3D form. As a result, after coming up with a drawing they liked, they immediately started sculpting a maquette.
With Margalo, they had a really good maquette that was cute from the beginning, and they could always go back to that maquette and look at the qualities. Having this stronger start actually made it more worrisome when they initially put feathers on her and felt that she wasn’t cute anymore. They had to figure out where the cute went.

Lighting was another factor that could make or break Margalo’s cuteness. They had to light the digital characters to whatever was shot on set and they didn’t get those plates until after the movie has been cut and they were formally in post-production. Then it’s a mad rush while fifteen to twenty artists are all lighting Margalo at the same time, all trying to find out what is the best level of key lighting, does she grin nicely, what’s her best side, how is she acting. During this stage, there’s always a period where the character looks terrible, and they had to figure out what went wrong.

Reality vs Fantasy

Since they were working in a live-action world, there were certain physical laws that the viewer expects subconsciously. You’re watching humans, cars, buildings, the sun and flowers, and if you suddenly have a shot where the character is breaking all sorts of physical boundaries, that will tend to yank you out of the environment. Subconsciously, human beings know when a digital character is wrong. It was Imageworks’ job to determine why it doesn’t work and then make it work.

The line was blurry. Margalo needed to be able to raise an eyebrow, which would never happen in the real world. Since you hear a human voice behind it, you’re going to expect some human traits to come out. But since you’re looking at a bird, you expect it to be birdlike. Mixing the two together seems to work – but they had to find exactly the right mixture. New issues came up with nearly every shot depending on how the line was read and on what the character needed to do.
For example, Stuart, when he gets nervous, gets more mouse-like. His ears twitch or he’ll wiggle his nose, or sometimes he’ll rub his hands together or his whiskers will twitch. The same thing with Margalo, when she was a little bit more nervous, she became more birdlike. But when she was talking, and being gentle, she was much more human because at that point she needed to connect with the viewer.

A mouse’s body was fairly easy to transform into a very humanistic physique with a mouse’s head on top. They simply couldn’t do that with Margalo and Falcon. They had to give the birds the ability to perform physically in a way that maintained their believability as birds yet allowed a performance that conveyed their characters. Because these characters were anthropomorphized, they needed to give the birds a range of motion and play with their anatomy so that they can do things that a real bird would never do.

A real bird’s anatomy is full of problems when adapting its physique for a human-like performance. A bird’s knee bones are hidden inside its torso, which gives the appearance that its legs bend backwards (it’s actually the ankles bending). The torso tends to be more horizontal whereas the head is above the body and appears to be vertical. Their wings, of course, are meant to fly and are designed specifically to do what a bird needs to do to fly.
They had to figure out a way of conveying both of those different anatomies on the same bird, two different styles of motion on the same bird, what is birdlike and what is humanlike. They had to cheat and make Margalo's feathers become fingers, which in the case of a classic 2D animation is easy to do. But when it comes to physiquing and setting up the actual controls and the skeleton for it, it is extremely complex.

Skin has a very dynamic range of motion; it's very elastic. They had to design in that elasticity in the way the skin folds around the bone structure in a way that would be appropriate to the character's body and movements.

The sweet spot was maintaining the physics of a bird wherever possible and adding in humanistic movements when necessary to convey a performance. They tried to maintain a birdlike style of movements and range of motion and only got into more humanistic traits for specific performance moments.

Research & Development

Just as Stuart's design began in research on real mice, designing Margalo and Falcon started with research into real birds. Birds do some incredibly dynamic things in the simplest actions. Though we don't think much about what makes a bird a bird, we see them everyday. If someone tries to animate one and they don't do it right, it stands out.

The artists took numerous trips to the Los Angeles Natural History Museum where there's a huge collection of birds that they could look at. The limitation there was, although they could see different species and colorations, they couldn't manipulate them and see how they moved.
For that, Dr. Stuart Sumida, professor of anatomy at Loma Linda University, came in. He has an immense understanding of both animal and human anatomy, which enables him to compare equivalents in different bodies. He had lectured many times when they were working on Stuart’s design, and he was a great reference for figuring out how to make a bird act like a human. Lastly, they looked at a lot of footage of birds. Fortunately, there are many documentaries with amazing footage of birds, including high-speed photography that captures tremendous detail.

They collected hours and hours of data, including photographs and video footage. Dave Schaub, one of the lead animators, went through all the material and selected what was relevant. Then he built a website and created a little interface for it, with neat little pictures, and labeled it all. The animators could go onto this website and get nice selected pieces of reference. Everyone had access to it and when the animator was in the “sweatbox” (a dedicated room where animators are called in, one at a time, to review their shots with the animation supervisor), they could call up the reference and say, “See, this is the kind of thing we’re going for.”
Don’t Read This if You’re Squeamish

First of all, NO living creatures were harmed in the making of this film. All the birds described below died of natural causes.

After Margalo was originally identified as a lesser American goldfinch, they kept several of them in cages for the purpose of studying them. One day, they found that one of them had died. They realized it would be good for research, so someone put it in a paper bag and stuck it in the fridge. Later, they took the poor bird out, pinned it to a big board and photographed it in different poses.

While they were out on the balcony taking these pictures, they looked down and saw a dead pigeon lying at the base of the balcony two stories down. At that time, there were plans for a pigeon in the film. One of the modelers went down to grab this poor dead pigeon. They brought him upstairs and photographed him too. In pursuing realism the Imageworks team took advantage of every opportunities for reference purposes.

Designing Margalo

They had compiled dozens of pictures of birds from nature books, the Internet, television, sketches. They started to focus on the songbird world instead of field birds because songbirds have a lot more color, they sing, so they’re just more interesting characters. They went with a lesser American goldfinch, a bright yellow bird with brown coloring in the wings. Finches also have a very small beak, short face and large eyes and they look more gentle naturally. The designers took that image and started exploring different angles. They ended up giving her slightly smaller feet and a more pear-shaped female form.

The design took off from a drawing that defined the basic nugget of her character, defiant and spunky with overtones of Amelia Earhart, the independent adventurer. In that drawing, she wears an old aviator helmet, goggles and a scarf. Lead modeler Henry Darnell began sculpting her and, after a dozen or so sculpts, everyone knew that was it. They arrived at Margalo definitely quicker than it had taken to arrive at Stuart three years earlier.
The wings required a lot of cheats. At first they thought that Margalo shouldn’t be able to use her wings as hands at all because it would be too odd. But that was like tying her arms behind her back, so she could only act by thrusting her head around, and that didn’t work either. They had to allow the bird characters to use their wings by bending them. Then they decided to see if they could make the flight feathers like fingers, so Margalo could actually pick things up. Once again, they had to find that line where she was both believable and still birdlike.

That created a scaling issue. When she’s flying and doing birdlike things, her wings are longer, and when she has to gesture in some humanistic fashion, her wings are shortened considerably. They hid it by scaling the wing as they moved from Point A to Point B, so the difference between the two isn’t obvious. But if you look at it, you’ll notice that whenever she’s gesturing, her arms are just shorter. If they had kept them the same scale, the wings would have been like 8-foot long arms. There were also a number of cheats to scale her legs longer or shorter, to get Margalo to pose in certain ways. The main issue was making sure they built a model where they could cheat whenever it was needed and, of course, hide it into the shots so that nobody would notice.

Also with regard to scaling, they had to pay close attention to the size of her head because she doesn’t have ears. They would constantly put Margalo against pictures of Stuart, who does have big ears, to make sure that they looked good together. Putting the helmet with goggles sitting on the back helped to close that gap.
Margalo’s Color Scheme

After the clay maquette was chosen, Gentle Giant made a dozen resin maquettes, which they lined up. Now they were all the same physically and it was just about color. Yellow was a favored color from the beginning, but they explored bluebird and robin colors and black with red accents. The American goldfinch that Margalo was originally modeled on has black wings. They gave that a try, but the black wings were just too dark and dull for the leading lady. In fact, all the darker colors seemed to be a little bit more serious, a little more brooding, maybe more intimidating to Stuart, and the brighter colors seemed happier, fitting the storybook world.

From the beginning, they wanted separation of color between the front and back of the wing. Because it’s a very long flat shape, a single color would make it very easy to confuse perspective. A light color on the inside and a dark color on the outside helped to convey her gestures.

The director wanted to pursue colored irises with pupils, which opens up her personality a lot more, enabling her to shift her eyes around while she’s still looking in one direction. They tried numerous colors.

One day, a group of us were sitting in a conference room with the director. There were a bunch of kids running around and a little girl walked by and she peeked in the room. Director Rob Minkoff invited her in, pointed to the maquettes, and asked her, “Which one do you like the most?” She went straight to the brightest yellow bird that was on the table. We all knew that the brighter colors looked good and really vibrant yellows were happy. And this girl went right toward that. It validated our choice and helped to steer the direction.

—Jay K. Redd
The Eyes Have It

One of the things that they found early on when they were doing research on the first Stuart is how eye placement defines the character. Most predatory creatures (including humans) have eyes in front of their head so that they can see very clearly and have great depth perception, which allows them to identify and pinpoint where their prey is and attack and capture that prey. Most non-predatory animals tend to have eyes on the sides of their heads which allows them to look backwards and forwards, giving them much broader range of motion with their eyes and a better ability to see when their predator is approaching from behind.

Stuart and, now, Margalo are both non-predatory creatures and so would have similar eye placement. One good result of that would be that, from a design point of view, it would help to put Margalo in Stuart’s world, to help them fit together visually. But it wreaked havoc with expression to put their eyes more on the sides of their heads.
With Stuart, they tried to get expression with his brow line but Stuart’s brows run horizontally, not vertically up and down on his head, which makes it very hard to describe his expression. Margalo has that similar problem and so they deliberately cheated some of her design to give her more forehead just so that they could give her a brow and, of course, for the cuteness factor, also gave her very large eyes. They wanted to give Margalo eyebrows, so they deliberately played with the color to give her a lighter colored eye shadow with a darker color above. That implies a hard line where the eyebrow would sit, giving them another tool to convey emotion.

Stuart’s eyes are black orbs, but the director wanted Margalo and Falcon to have colored irises. With a colored iris, they were afraid that Margalo might look googly-eyed. They thought that as the animators positioned the eyes, it might be difficult to modify if she looked funny. It turned out not to be a big deal, and having colored irises did give Margalo more life and character.

For Falcon, they tested different colors for his irises, starting out with a red-orange color, similar to Margalo. They tested that color with very small eyes and they looked really goofy. Next, they went with a pretty large iris and changed the color to blue, which worked much better. A cool new feature was a control allowing the animators to make Falcon’s pupils dilate. That data is passed on from the animators to the shaders and the shader actually controls the texture that maps itself onto the surface.
Designing Falcon

Falcon was always supposed to be the most realistic of all the characters. Because any predatory bird, falcons in particular, are so inherently menacing looking, they wanted to maintain that and they thought the best way to do that was to stay real.

In the original script, the character is a hawk, which is a very different bird from a falcon. Hawks don’t live in buildings, and peregrine falcons are known to live in skyscrapers all over the country, even in downtown Los Angeles. They looked at different falcons and hawks, talked to Boone Narr, the animal trainer who worked with Imageworks on the first film, and videotaped half a dozen different types of birds. They also spent quite a bit of time at the Los Angeles Museum of Natural History, where they had access to drawers full of 80-year old peregrine falcon skins. That helped them to study the feather patterns and see how they’re stitched across the skin.

The director liked the peregrine falcon the most, because it wasn’t too big, which meant it could fit into the film’s world well, and because it has beautiful feather patterns. But that created a conflict. To keep costs as low as possible, they wanted to be able to cut from shots of live birds into CG, for close-ups and landing/take-off shots. But peregrine falcons are endangered and they wouldn’t be able to use real ones in the film.

They also learned that the lanner falcon was very close to the peregrine and not endangered. That enabled them to shoot a live falcon on stage, which they ended up using as a flight reference or a lighting reference. At the time, they thought if it looked good and if it cut with the storyboard, they would keep it. Otherwise, they figured they’d shoot the clean background with nothing in it so they could do it digitally later.
Matching the Real World

Creating the digital Falcon originally posed the challenge of matching not one, but two other falcons. Not only were they planning on using live-action shots of a real falcon, but also The Jim Henson Company was building an animatronic Falcon. The path of pursuing an animatronic falcon was a great research experience. During the time that the animatronic was being built, Imageworks’ computer artists worked hand-in-hand with the animatronic artists, sharing information on how the feather patterns are built and doing movement tests. They completely deconstructed a peregrine falcon, from the skeleton to the very tips of the feathers. Imageworks scanned the falcon model created by the Henson Company and were able to use that as a starting point for their digital model.

For a variety of reasons – the difficulty of matching performance between live or animatronic falcon and a digital one, and the fact that they could get better performance and emotions from a digital character – they abandoned the idea of intercutting real footage or animatronic footage. Even more fundamental, after the production shoot was completed, the look of the falcon was changed, which meant it wouldn’t have been feasible to match the animatronic or a real falcon. They ended up building a fully digital peregrine falcon. Though there are no live or animatronic falcons in SL2, these falcons did provide a great deal of reference and were a great help in building the character.
Falcon’s Facial Expressions

A falcon is a naturally threatening looking bird, making him an ideal villain who poses a credible threat to Stuart and Margalo. But what they hadn’t counted on is that falcons, in addition to being intimidating, are also very beautiful, majestic-looking birds. After Falcon was built, he looked more beautiful than scary. Imageworks ended up dirtying up his beak and his face to make him look more mean than majestic. They also took some liberty in changing some of the patterning on the head; the head is a little bit lighter gray than it is in the real world, and they took some of the hair away around the beak and some of the coloring off the chest.

One thing that helped is that falcons have a very heavy brow line over their eyes, which tends to convey a permanently angry expression. This furrowed brow said so much about his character. Even so, once they started actually performing with him, they needed him to look something other than angry, and that wasn’t easy. They had to maintain his volume, meaning once they defined that Falcon has a heavy brow line, that heavy brow line can’t just go away. The trick was to design expressions that maintained the volume yet conveyed emotion.
STUART LITTLE 2: Let the Feathers Fly
Modeling Margalo

For the development artists creating drawings of Margalo, the challenge was that, in the 3D world, she has to look good from every angle. After getting to a basic design quite quickly, Darnell and supervising modeler Kevin Hudson started developing maquettes and quickly found that, despite the fact that the basic design had been relatively painless, getting that last ten percent – to create that final cute face – was still time-consuming.

For Margalo, the modelers created three different bird bodies based on the basic shape of a small songbird or pigeon. That evolved into her body shape, based on a lesser American goldfinch. The trick for the look development team was to get this lemon-shaped (and colored) bird to look interesting.

Once they had a body and a head proportion, Darnell made at least two dozen different heads for Margalo. The head was going to sell her personality and express cuteness. Whereas with Stuart, the challenge had been getting the basic proportions, such as his arm length in proportion to his body, with Margalo the sweat came in the details.

And her small head — which they referred to as a ping pong ball with a beak — was full of crucial details, such as size and placement of her nostrils, the size and curve of her beak and the positioning of her eyes. One of the things they had learned with Stuart is that, if they wanted the face to look like it’s really moving, they needed to have different volumes in the face to play against each other. It’s the cheek up against the eyes that gives the smile. It’s those shapes playing against each other that communicate. They gave her a brow muscle by accenting it with some feathers and a bit of a human cheek. Her eyes were at about a 45 degree angle, like Stuart’s and have a colored iris. Darnell dealt with the issue of eye placement by putting her eyes more forward on her head, so that she could have binocular vision and not look like an alien or cross-eyed, but not so forward that she would look strange. The artists needed to define that balance, where she could be cute and perform – and still resemble a bird.
They ran into another issue that was familiar from the first movie. Everybody liked the drawing of Margalo with a big smile, rather than in a neutral pose. Similarly, in developing Stuart, it was hard for anyone to relate to any drawing or model of Stuart in a neutral pose. For that reason, all the maquettes were sculpted with a smile on Margalo’s face.

As soon as they found that her neutral pose didn’t look as cute, they readdressed her design to allow for a neutral pose that looked good. They went back to the modelers who gave Margalo some nice puffy cheeks. Now, when she wasn’t smiling, they were able to puff up her cheeks in the model, which helped to round out her face. Additionally, with the hair added on her face, she became cute again.

How feathers would impact the face shapes was something else to consider. After the Margalo look team settled on a combination of feathers and fur on the face, they had to adjust the face shapes to make them read properly. The majority of the face shapes were sculpted by modeler Beau Cameron who had a good eye for sculpting shapes that not only were cute and expressive but also felt innately female. Margalo’s expressions are broad but they’re not angular, they’re always soft. Balancing broad but soft performance was what gave her a “female” identity. In the modeling of face shapes, the other challenge was having a beak that could bend somewhat but still remain beak-like.
With Stuart, they found that once they added his fur, it took away about twenty percent of the dynamics in the expression. It softened everything. While they assumed that feathers would do the same thing for Margalo and Falcon’s design, in reality, what they found is that feathers often strengthened expressions or could point out the flaws. If they had bunched up points too close together somewhere or stretched them too far apart somewhere, the feathers really showed that off. And, whereas fur hid a lot of those problems, feathers just made them bigger.

Margalo was very delicate and dainty, but they knew from the beginning that her feet were one feature that had the potential to look very scary like a real bird’s feet. They had to decide what to do with her claws and went through four or five revisions until they found that perfect balance between her having substantial enough claws to hang onto something without looking like intimidating talons. It ultimately came down to the fact that they don’t show her feet close-up very much.

They sculpted Margalo in the computer as a full bird volume and then shrink-wrapped her to make up for the volume of feathers.

**Look Development for Margalo**

After Margalo was modeled and the feather pipeline had been developed the featherless Margalo came to the look development team, led by technical director Virginia Bowman, which was in charge of implementing all of the technical and aesthetic decisions made about her look. These decisions included defining feather coloration, size, softness and patterning. In addition to the feathers, the look development team was responsible for all the texturing and shading for the beak, eyes, feet and the mouth.

For feathers, working with the tools created by the feather R&D team, texture painter John McGee created about 20 different layers to describe the qualities such as length, width, shape and downiness of the feathers on the different regions of the body. He also created maps that defined the regions of the face and armpit for which they would apply fur rather than feathers.
Margalo’s face had to be very expressive, and they discovered that the smaller the feature, whether that be feathers or fur, the more the expression could be read. Thus they chose to use smaller feathers and fur around the highly detailed parts of the face. Fur was used in addition to feathers because, when feathers get sufficiently small on a bird, the human eye simply perceives them as fur. If you look at a baby chick, its down looks very much like fur. It didn't hurt that this furriness also made Margalo look cute. Striking the balance between large feathers, small feathers and fur was a significant part of the look development team’s contribution.

For Margalo’s eyes, they started by using Stuart’s eye shader and then extended it to include support for two surfaces: a semi-transparent cornea and the surface of the eye, which includes the iris. The pupil size was driven by controls from the animator’s scene file. Shader writer Brian Steiner initially designed an iris displacement shader that would cheat the shape of the iris to account for the refractive effects of the cornea. This effect was quite convincing but would often yield a result that made Margalo look cross-eyed or wall-eyed. Thus, in the end, they chose not to use this effect.

The beak and the feet of a bird have many of the qualities of a human fingernail. They are the result of several levels of very thin, semi-transparent material layered on top of each other. Most important to achieving a realistic looking beak and feet were two qualities: translucence and specularity. Pixar’s RenderMan® doesn’t calculate volume effects directly, so they simulated the beak’s translucence using Ktr, a shader “cheat” that simulates light passing through a translucent surface. Ktr considers the entire beak hollow and only calculates for surfaces, making it illuminate on the opposite of where the light’s really hitting. With volumetric objects like the beak, the result made it look thin as an eggshell. To give it more volume, they also incorporated a shadow map to darken out the core.
Modeling & Look Development for Falcon

They modeled Margalo first and because Falcon followed along the same lines, the process of modeling him went more smoothly. They learned an incredible amount from modeling Margalo, especially as regards the challenges on the physiquing end, of creating a realistic bird that is completely believable but can also perform as a human character.

The modeling and look development teams relied on a “Falcon Bible,” a collection of images of real peregrine falcons, which was the look they were going for. Everybody was so convinced that what they wanted was a real falcon that the initial look development focused on a real falcon. Ultimately, what was needed for the movie was something that would fit stylistically with the other digital characters, which are much more caricatured. In other words, Falcon needed to fit into Stuart's world. Modeling adjusted Falcon's shape, making his chest a little bigger and thus more intimidating.

Additionally, they decided after seeing the first tests of his look that he didn't appear menacing enough. The Falcon look development team, led by senior technical director Bob Winter, had come up with a very realistic looking bird. The goal became to make him look a little meaner and scarier. They added some decaying colors in the cuticles, desaturated some of the deep colors, and gave him longer, scragglier hair, which made him look older.

Falcon's face went through the same developments as they did with Margalo. They had to figure out how to get his big, hooked beak to look right. With the beak, they had to balance softness and rigidity. Unlike Margalo, they made it so that, as the beak gets further back, it becomes more movable, and closer to the hook, it becomes more rigid. That way, they made it believable, but didn't sacrifice the performance.
The only other modeling challenge with Falcon came when it was decided that they really needed two falcons. The feeling was that putting the main falcon into a flying pose created problems with proportion; the feet seemed large and dangled down, the chest seemed large. It was decided to work through physiquing, scaling things, to create a falcon that was more appropriate and aesthetic in a complete flight pose. This “flight” falcon had shorter, more pulled-in legs. The “performance” falcon has a much more tapered, human look whereas, when he’s in flight pose, he looks like a real bird flying. That gave them the more humanistic performance they needed when he was walking around, talking and gesturing. The body fits the behavior.
Modeling Wings

Creating wings that were naturalistic and could both fly and perform was even more of a team effort than usual. Modeling first created the wing shape, but the other departments had to decide what their needs were from that wing shape.

The modeling department had a unique challenge in that it had to model what a real bird does but what they did also had to work with the feathers. They then went through the process of replicating how a real bird’s wing folds on the computer, shaping it so that, when the wings folded, the feathers didn’t move strangely over the surface. Since the feathers weren’t there, the modelers relied on the feather team to do tests. After sculpting the shape, they handed it over to the feather team, which put the feathers on and rendered it overnight. The next day they would see how it all came out. If the geometry didn’t work, the modelers blended shapes to smooth it out.

Physiquing Wings

Margalo and Falcon are, for all intents and purposes, one and the same from the point of view of physiquing. By far, the greatest challenge for physiquing and character set-up was the wings. The wings had to do a lot: they had to fully spread out to fly and to fully contract into a tight, closed-up pose. Each flight feather (and there were 20 per wing) had to be individually rigged. The four flight feathers on the tip of each wing had to be rigged so they could perform like fingers. And the skin of the wings had to be weighted to the wing bones. Wing bones and feathers had to be scaled to achieve human-like arm and hand poses. All of these requirements posed significant challenges.
Previously, the method of physiquing a character was a linear process. After the model was created and approved, it was handed off to character set-up. The model itself was constructed in a neutral pose that was deemed to work best for all or most of the possible poses. The birds required a quite different process, however, which they discovered through trial and error. The birds needed to look good in two key poses — wings open and wings closed — that are dramatically different.

The drastic differences between the two extreme shapes meant that, although it had been a goal, physiquing couldn’t do all the deformation. Once the wing was physiqued to work in closed wing pose, the model was sent to the modeling department to smooth and shape for a final closed wing pose. Senior modeler Dustin Zachary created blend shapes with three intermediate stages between the extreme open and closed wing positions, but ultimately they found that the birds worked better with just two shapes.

Because of the complexity of the controls, a pose for the closed wing had to be predefined. This entailed closing the wing to match a real bird as closely as possible. Once the wing is closed, the feathers are manipulated and tweaked until they are packed tightly together.

A big part of the success was the one-button pose set-up established by senior technical animator Aaron Campbell, who had done character set-up for the first Stuart, and in this film, set up Stuart, Margalo and Falcon. With one button, it was seamless for the animators to go from open wing to closed wing and in between, without the huge nightmare of feathers going everywhere. The animators could treat Margalo’s wing like an arm and be pretty happy with the results.
Rigging the Wing

After the model was finished came the next step: the complex wing rigging. The rigging architecture was designed in three layers. First, bones in the arm were built in the same fashion as a real bird. The animator rotates these to get the wing pose. Second, a simple 4-point curve defines the profile of the edge of the feathers. The curve is automatically driven by the bones in the arm, but additional controls are given to the animators to further sculpt the edge of the wing. Third, each individual feather has automatic controls that bunch the feathers together when the wing is closed and evenly spread the feathers when the wing is open. This layer of rigging addressed all the potential problems of feather interpenetration. The controls keep the feathers from crossing each other and keep them interlocked with each other, thus reducing feather-to-feather penetration to a minimum.

Additional feather controls are added to scale, bend, shift and tweak the feathers to allow the animator to get any pose from real-life bird to more human-like hand gestures. The four feathers at the tip of each wing got their own set of controls, to be able to be animated like hands.

Building the Skeleton

1) The modeling dept. provides a set of feathers using Imageworks' custom feather building plug-in. 3 joints are draw inside the shaft (joints B,C,D) and a 4th feather is drawn from the base of the feather to the closest point on the arm (joint A).
2) A base joint is created from the base of joint A to the tip of joint D. The ABCD joint hierarchy is then parent to the base and the base is parented to the closest arm joint.

Building the Guide Curve

A simple 4 pt, or cubic curve is build at the tip of the feathers. While the base of the feathers are attached to the arm joint, the curve at the tip will define the curvature of the tip of the feathers. Each point is clustered and parented under each joint. A cubic curve was used because it is simple, less controls for the animators to deal with, and each point corresponds to one arm joint.

Building the Guide Joints on Curve

A custom joint chain is build on the curve. Each base joint aims at a corresponding joint on the chain. The Chain will keep an equal distance on the curve, or change the spacing between feathers without crossing over.

Building the Batwing

Using all the feather joints in the wing a NURB surface is drawn using each joint to define the position of each point. Each point is then clustered to the corresponding joint. The batwing acts like a piece of paper with each feather lying on top. This helps keep the feathers locked closely to each other without passing through each other. It also is used to drive the chicken wing, and define the direction of the procedural feathers.

Building the Feather Barbs

The last step creating the barbs for each feather. Six barbs are build, drawn from the joints in the shaft to the edge of the feather, following the UV direction of the feather. The tips of the barbs are constrained to the batwing creating the automated system to keep the feathers flush to the batwing. Additional controls are added to scale (width and length), rotate the edge of the feathers, and give the feathers more cupping.
Getting the Wing Right

After the closed wing pose was completed, the wing was sent back to modeling to clean up the unwanted bumps and creases. The wing’s size was also increased and rounded to get a nice closed shape. There was a fair amount of “back and forth” between physiquing and modeling to get this right.

Aaron would do a quick physiquing in the open wing pose by weighting it at the joints, and then put it in a closed wing pose, just to get a rough idea of the positioning. Then he’d go in and change anything on the model that needed changing so the pose would work. This went back to Zachary who would remodel and tweak the bird. This back-and-forth process continued until they got the open wing.

One of the things they learned with Margalo is how crucial the model was from the beginning to get the physiquing to work. Because they initially thought she was going to be more human-like, they put the wing in the approximate center of the torso, whereas, on a real bird, the wing connects almost at the back. Because of this, when they closed the wing, it just didn’t look like it was in the right spot. The feathers would occasionally do strange things as they went from open to closed pose and vice versa.

For Falcon, they tweaked the model by pushing the wing back to get it much closer to a real bird’s anatomy. When Falcon went into closed wing pose, it looked really good almost right from the beginning. The modelers just had to do a little bit of shaping.

Finally, physiquer Chris Waegner carefully weighted both Margalo and Falcon. This was very difficult, because the birds did not have defined neck, shoulders, arms and legs. They had to look like a tight ball of feathers in closed pose, or have shoulders and forearms in open pose. Plus, they had to hold up when scaled. This was achieved by setting up a lower resolution skin that drove the higher-resolution skin. Waegner also added several custom deformers to adjust for the harder poses.
Animating the Birds

With Margalo and Falcon, the animation team had to get to know two entirely new characters from an entirely different species. Although it might seem that getting them to fly realistically would have been the paramount challenge, in fact, the act of flight is a very mechanical process, governed by laws of gravity and aerodynamics. To achieve flight that looked realistic wasn’t easy, but the animation team was able to study those mechanics - which are very well documented - and then replicate them. Some sequences really showcase the successful work done with flight. The falcon’s amazing aerial ballet to get into a position to dive towards its prey is one such example. To get the proper motion blur for the wings in flight required sub-frame animation, which meant the creation of key frames on just about every frame and points in between.

Though the animation team had plenty of photographic references for the mechanics of flying birds, the trick was when one of the bird characters was flying and talking at the same time. Ordinarily, when a character is speaking in an action sequence, the camera cuts to a close-up of the character, as the background whizzes by. For some reason - probably because we’re not used to seeing a talking bird in close-up while the background speeds by - this didn’t hold up well in animation. Performance moments in the middle of flight sequences were difficult to resolve and required careful planning and reworking to find the right balance.

Personality was certainly the most subjective part of animating Margalo and Falcon. So much of performance comes from body language, as opposed to actual dialogue. The animators’ challenge was to find a way to both anthropomorphize the birds and allow them to keep their bird-like qualities. The solution was to showcase bird-like animation during more action-oriented scenes, and focus on more humanistic animation during the more emotional scenes.

Margalo is able to gesture with her wings and her flight feathers, which double as hands in the more emotional moments. But Falcon’s wings were far too long to be able to scale to a size that would permit humanistic performance. As a result of that - and because the animation team was trying to make Falcon as intimidating as possible - they came up with the idea of using his very sharp claws as hands. Also, to make Falcon intimidating, animators made a conscious decision to fill the screen with him. For example, when he’s speaking, they opened his wings wide, which gives him a bigger presence and makes him appear scarier.
Beak Speak

The birds’ beaks were another issue. They had to find a balance between allowing the birds to speak without the beak becoming too rubbery. The compromise was to allow the tip of the beak to form expressions, keeping the rest of it more rigid. This gave them at least some ability to form different shapes for the birds to talk and show expression. For Margalo, softening the beak also helped to identify her as female.

Falcon, however, is a predatory bird with a hook-shaped beak. Because he’s a very mean, intimidating character, they couldn’t allow for too much of a softening technique on the beak, which would take away from his threatening personality. That made it difficult for them to push the phonetic shapes needed. They ended up playing more with the corner of the mouth, allowing a greater range of motion there.

Then they discovered with both Margalo and Falcon that, when looking straight down their noses, if the sides of the mouth do a lot of forward-and-back movement, the beak looks quite rubbery, but that same motion from a profile looks completely natural. They learned that they had to be very careful with how far they moved the corner of the mouth. Whether a movement worked or not depended on the character’s orientation to the camera.
Streamlining Stuart

Stuart didn’t – and couldn’t – change too much, because he needed to be consistent with the Stuart that audiences already knew and loved. Hudson and Darnell gave the existing Stuart model a rough polishing, to make him ready for his many close-ups in SL2. First of all, he needed more anatomy because, in the new film, Stuart takes his shirt off. In the first movie, he had a body under his shirt, of course, but it was polished smooth, in part because they didn’t want any problems with his clothes interacting with his skin. Fur would have been a potential complication and, since his torso was covered with clothing, he didn’t need it.
But, now, in SL2, all of a sudden, they needed to create a torso with more shape and add fur. The good news was that they had learned on the first film that cloth isn't as fussy as had been feared, so they didn't have to worry much about problems of the cloth interacting with the fur.

The modeling team also took the opportunity to refine and modify Stuart's neutral pose. A neutral pose is the shape he takes when no animation controls have been applied. In the first movie, he was posed with his arms straight out, in what they called the DaVinci pose, after that artist’s famous anatomy drawing. For the second film, Stuart is in a more relaxed, rotation neutral pose, where the angle of the arms is midway between either extreme. This made his de facto pose more natural, helping to avoid creasing and other artifacts.
Physiquing the New Stuart

Since the first “Stuart Little,” technology had advanced and Imageworks’ experience had deepened, which enabled the physiquing team to completely redo the controls of character setup.

Because Stuart is a bipedal character, physiquing him was fairly straightforward. But, for “Stuart Little 2,” a lot of controls were added to Stuart, which helped the animators, especially since Stuart is so much more active and interactive in the storyline. For example, the team created a more complex foot set-up. The old Stuart could only rotate from one point on his foot. They set up the new Stuart so he could pivot from any part of his foot and also roll his foot from side to side. This gave the animators extra options and helped in the difficult task of “grounding” Stuart in the sequences in which his digital feet interact with a real or virtual world.

Another useful option they created was more controls for Stuart’s spine. Normally, they could only rotate from the pelvis, but they added controls so that the animators could also rotate from the shoulders. Now, when he’s flying or being carried off by Falcon, he could rotate from the top of his body down to his feet, as opposed to from his pelvis to his head. In character set-up, everything’s a hierarchy, so if Stuart were swinging from his arms and the animator could only rotate from the pelvis, he’d have to counter animate which takes longer and is more painstaking. Having those extra controls just made things more intuitive for the animators.

They also set up Stuart so he could have either forward kinematic controls or inverse kinematic controls. They also added an IK set-up for the head which means that with just one control the animator can rotate the head and that will rotate the neck with it. In the first movie, Stuart had just forward rotation on his head.
Another important addition to the new Stuart was eye shapes. Because Stuart doesn’t have any pupils, it was very hard to show the direction he was looking in the first film. In “Stuart Little 2,” supervising technical animator John McLaughlin wrote a system, whereby the shape of Stuart’s eyelids move or change with the orientation of his eyes. In SL2, now there are a couple of shots where his eyes are doing little furtive glances that never could have been done on the last film. The physiquing of the face had to be combined with the shapes that define the brow movement – with blink controls, added automatic eyelid control that follows the direction of the eyes, and appropriate distortion of the eyelids.

Finally, technical animator Alan Lehman weighted Stuart’s skin with the latest off-the-shelf and custom deformation tools, greatly improving the weighting on the second Stuart. The improved skinning helped save on per shot clean-up.

**Animating Stuart**

For SL2, the animators had a chance to evolve Stuart, giving him more subtlety and range. One of the challenges in animating Stuart is his tiny size vis-a-vis his environment. In the first film, that issue was sidestepped by having Stuart be carried from location to location in one of the live-action character’s hands. In “Stuart Little 2,” Stuart gets around on his own steam. We see him walk into his home carrying Margalo and making his way across a huge room. We see him climbing down from a desk. Because of the huge difference in scale between Stuart and his environment, Stuart scampers like a mouse when he needs to, without losing his humanistic qualities.

There were also quite a few more performance challenges with regard to interactions with the real world. For example, Stuart pulls his shirt off, takes off his backpack and interacts with his clothing in many scenes. To make it work, the animation team did an unfinished animation and sent it to the cloth team, which “dressed” Stuart. They then sent it back to the animation team to fix anything that didn’t work. This kind of back-and-forth was time-consuming but crucial to make Stuart work whenever he interacted with clothing, props or people.
The Cat’s Meow

“Stuart Little 2” marks the first time Imageworks has been involved with the talking cats. For the first film, they handed off all the talking cat shots to Rhythm & Hues and Centropolis Effects. In “Stuart Little 2,” although there are fewer cats – Snowbell is still the star and there’s only a cameo of Monty — there is far more cat animation than in the first film.

This time, they decided they wanted to do it themselves but, due to production time constraints, Rhythm & Hues ended up working on several of the shots. Rather than work with face shapes, as they did with the other digital characters, supervising cat physiquer Alberto Menache and his crew created a muscle system from scratch, which duplicated the musculature of the cat. They laid it over the top of a skeleton and then added skin to it, allowing the movement of the muscles to move the skin the way real anatomy works.

The benefit of that technique is that it’s easy to take the animation off of one character and apply it to another if they are of a similar structure, because 70 percent of the animation is its range of motion and the rest is to get a specific look. The biggest concern was whether they would be able to do what they needed to do in the given amount of time since the R&D schedule was very short on this film.
Boone Narr’s team from Animals for Hollywood once again trained the live action cats, upon which all the digital performances would be based. Performance is all about body language and facial animation is icing on the cake. It’s the last thing the animator puts on the character. Because Rob Minkoff is a former animator who knows the animation process inside out, he was able to select takes where the cat’s body language conveyed the performance he was looking for. And that’s hard to do with cats, because cats have subtle personalities. They shot many takes, sprayed air in their faces to get them to move, offered them treats and did all sorts of little tricks to get the cats to do what they wanted. Rob picked out the best performance footage, and Imageworks (and R&H) put the faces on them. Still, the process was fairly quick, because Minkoff had picked the body performance and the animators just had to concentrate on the facial animation.
STUART LITTLE 2: Let the Feathers Fly

Feathers
In Summer 2000, the feather R&D team, led by CG supervisor Rob Engle, got started on figuring out how feathers would be created. To create feathers, they wanted to take what they learned on the first “Stuart Little” and apply it to “Stuart Little 2.” They knew that, just like creating fur was crucial to the believability of the main digital character in “Stuart Little,” so the ability to create realistic feathers would be the building block for SL2’s new main characters.

Key personnel on the software R&D team were senior software engineer Armin Bruderlin (who had worked on Stuart’s fur for the first film) and senior technical director Gokhan Kisacikoglu. Later, software engineer Jeffrey Chan and technical director David Tanner joined the team to lend a hand to, respectively, address interpenetration and build geometry blending tools.

Fur vs Feathers

The first question that came up was whether they would need to create actual feather geometry over the entire creature or could try and fake something. They quickly realized that in order to get the level of realism that they were hoping for, they needed to have actual feathers on the surface of the bird. Especially since they assumed from the outset that this movie was going to feature a lot of close-ups of the birds, they knew they weren’t going to fool the audience by painting feathers. They needed to have feathers that could slide over each other, interact with wind and react to collisions with other surfaces.
One interesting difference between Stuart and the birds is that, while Stuart’s fur isn’t specifically part of his performance, the birds were designed to use the feathers on their wingtips as fingers. Both Margalo and Falcon have feathers that are part of their performance, which meant they had to come up with a system that would allow the animators direct control over the finger-feather performance without having to animate all the other feathers. That was important since Margalo has over 3,000 feathers and 70,000 hairs that fill in the gaps around her face and under her armpits.

They used some of the same technology developed for Stuart’s fur and created new technology where it was required. They developed an entirely new instancing technology, which is the backbone of how Imageworks creates all the geometry. The same idea of using key curves to groom the character still applies on Margalo and Falcon, and the shading model is fundamentally the same although there are some new challenges because they needed to have a smooth transition between hair and feathers on the same character. The viewer should just sense that this bird is covered with finely detailed feathers, which are really hair, that finally become full-fledged, recognizable feathers.

With Margalo, they went through several iterations of just how much hair she had versus feathers, to toe the line between her looking cute versus looking real. Shader work was needed to ensure that the transition from feathers to hair would be undetectable. On the first SL, they learned that it helps to use the surface normal of the underlying skin to help drive the shading of the feather that’s on top of it or the hair, and that the more they used that, the more they got a consistent look over the whole bird. They could have a hair right next to a feather and as long as they’re both using the surface normal, they ended up with something that looks pretty much the same.

Margalo’s hairs needed to flow backward towards the back of her head, but at her beak, they needed to flip over, to create some sense of hair over her beak. Getting the hair from being laid back to being laid forward all in a very short space was problematic early on, because the part in the hair was visible. They had to do a lot of work to get the underlying skin texture to match the hair texture to make it less noticeable.
Defining a Feather

Dr. Sumida lectured on the structure of feathers. He described a feather as a central shaft or quill and a left and right vane. Each vane consists of a number of barbs which are like little hairs. The barbs have an interesting sub-structure with hooks, which allow them all to stick together like Velcro. That’s why the barbs stay together and become a very rigid surface, but will break apart if forced. The feather team decided it was an important property to be able to see these individual hair-like structures.

Very early on, the production wanted – as a proof of concept – to create a single CG feather. In parallel with the feather programming project, shader developer Brian Steiner produced a number of tests shading a single feather with the theory that you start with a single feather, make sure that it looks really good, and then create thousands of them.

We created several different versions of feathers, to make sure they weren’t going to create any weird aliasing or rendering artifacts, and put patterning on it to mimic the feathers of a peregrine falcon.
—Brian Steiner
To define a feather, the first and most obvious criteria are its length and width. Is it a very long, narrow feather, or a wide, fat feather? Another quality is its level of detail: How many barbs does it have? What is the width of each barb? Do the barbs stick straight out or curve more towards the end of the feather? Are the barbs nicely stuck together, as a perfect feather, or does the feather have lots of splits or breaks in it? These are just examples of the hundred or so parameters which described a feather in the feather modeling system.

**Feathering the Birds**

To model the feathers, they looked at real birds, whose feathers are laid out in tracts or lines that go down specific areas of the body, with the feathers radiating out diagonally from those lines. There are strips of unfeathered skin between these tracts, which typically are covered over and obscured by the neighboring tract feathers. The exception is a bird’s neck from which an immense number of feathers stick almost straight out. Fortunately, they weren’t trying to create a real bird with all of that extra complexity: They just needed to create a character that people could believe was a real bird. Therefore, their birds have thick necks, which meant they didn’t have to create all those feathers sticking straight out; with patterning, they didn’t need to actually lay the feathers out in tracts but just cover the surface.
They initially used tools built to create follicle positions for Stuart’s fur in the first film, but quickly determined that the technique they had used for randomly placing hairs just didn’t apply to feathers. With feathers, one can make out when two feathers are very close to each other and then there’s a big gap and then another feather. Hairs are so dense that that kind of detail isn’t visible. To solve this problem, they adapted an existing technique called “particle repulsion,” making two changes. First, the particle repulsion technique, as described by Paul Heckbert, was originally written to work with implicit surfaces. Technical director Allen Ruilova adapted this technique to apply to the skin on the bird, which was not described by an equation of an implicit surface but rather by a set of connected NURBS patches. Secondly, this implicit surface technique was designed to create an even density of particles over an entire surface, and they needed to be able to set up a variation in density over the whole surface.

They only used particle repulsion for placing the feathers. The hairs were created using the same technique used on the first “Stuart Little,” the old density function. The first step was to create the surface, then place the feathers, and then add the hair. Lastly, they had to be able to adjust everything manually. Like every visual effect, having control over it was crucial to making it work.
Creating Thousands of Feathers

To instance the feathers, they used a basic system — very similar to what they did for the fur on “Stuart Little” — that relies on key curves to describe the behavior of many more curves. This allowed them to place on the bird a couple of hundred key curves which describe the direction and orientation of the feathers and hairs, and then create thousands of feathers by interpolating between the nearest key curves. It’s a pretty straightforward technique with which to create complexity in a cost-efficient manner.

Early in the design phase the idea was to invest time and energy into a very open system that could generate any kind of geometry across the surface, making it more useful for future projects. They ended up with a system that is, in many ways, like a programming language for instanced objects. The skins of the characters are all based on NURBS geometry, and they created tools to instance geometry – in this case, feathers — around the skin. It could have been thorns, scales, grass — the same idea applies. This suite of tools basically allowed them to populate the bird with follicle locations, and set up parameters that described how the hair and feathers were going to look on the surface, in terms of shading and geometry. A feather’s length, width, shape, how many barbs it has, all of these parameters were part of the description of the bird and varied over the surface of the bird.

Additionally, since the feather team knew from the first drafts of the script that the feathers would probably need to be seen in a variety of environments (including a scene in which Margalo takes a bath), they decided that the system should be flexible enough to allow for any eventuality.
The result of these early design decisions was the development of two major components, the expression-based map file and the blend subsystem. The combination of these two systems would allow for any feather parameter to be animated in time or varied over the surface of the bird, even to use multiple feather instancing techniques blended together to achieve the desired effect. The system was also designed in a modular fashion allowing the introduction of new feather parameters, instancing and interpenetration techniques without the need to make sweeping changes to either the instancer code or to existing shots.

A final requirement of the instancing system was that not only would the animators need to be able to hand animate the “finger” feathers, the feather team would need the ability to adjust any instanced feather on the surface of the bird. This would provide for effects such as Stuart pulling a feather off the Falcon (an effect not employed in the final script) in addition to allowing feather TD’s to tweak feathers that just would not behave.

Grooming

An additional step in the modeling of a bird involved grooming. Technical Director Chris Yee was responsible for carefully positioning and orienting the approximately 200 key curves, which would determine the base orientation and twist of all the instanced feathers.

Grooming was much more crucial for feathers than for hair. Feathers are relatively huge, like big oars that stick out and look very different if they’re rotated ninety degrees. So they needed to add the ability, both in the automatic generation of primitives and in the grooming tools, to introduce twist, or the ability to turn feathers a certain direction along their length. For the most part, this task was handled automatically. They knew that if a feather were groomed down the length of the bird that they didn’t want it sideways with respect to the skin. But there were a few key areas, particularly the leading edge of the wing, where they needed to be able to twist feathers as they went along the edge of the wing. This was just another example of how the complexity of feathers introduced new dimensions of complexity to the overall feather pipeline.
The human eye doesn’t make out an individual hair unless it’s looking for one but, with feathers, we definitely observe individual shapes. As a result, what each feather is doing becomes very important. While the grooming on the bird ensured that it looked great in its neutral pose, when they animated the bird, the key curves didn’t necessarily behave well. The key curves went through the wing, which meant all the feathers would go through the wing as well. This problem was what was called “interpenetration” of the feathers with the underlying skin. Additionally, they also had to prevent individual neighboring feathers from interpenetrating each other.

The goal, of course, was that all of the feathers should be pressed against the surface in a nice orderly direction and orientation, but even when all the feathers were oriented correctly, individually they could interpenetrate each other or interpenetrate the skin. It would have been particularly noticeable with Falcon, whose feathers have individual patterns. Margalo’s semi-transparent feathers produced less of a visual problem.

To resolve the II4N challenge, they needed to create a system whereby the feathers didn’t interpenetrate and yet was flexible enough so that they could still control the feathers’ performance. This fundamental problem with feathers formed the core of the teams’ efforts for several months.

The initial solution they came up with was one-dimensional volume deformation (1DVD). 1DVD remembered, for all of the key curve CVs (control vertices), how far they were from the surface of the base model and the position of the closest base model surface point. Applied to the animation, the key curves were now “locked” so that, as the skin moved, the feathers stayed aligned with the movement of the skin.
This solution was particularly important for folding wings. They wanted the feathers to fold along the length of the wing and to align themselves to the back of the body. The only way to do that effectively was with the 1DVD technique.

1DVD did create its own set of problems. Most specifically, when the bird turns its head, the skin stretches diagonally across. They didn’t want the feathers to rotate with the skin because that gives the effect of a painted texture of feathers on the skin. Another problem with 1DVD was that it only described what happened to the shaft of the feather, not what happened on either side of the feather. For a very wide feather, for example, the curve described generally how it was bent and its orientation. But it didn’t help with having two feathers side-by-side that were interpenetrating each other.

To solve the problem, they tried a few different techniques, none of which were either robust, controllable or gave the desired results. One avenue of exploration was in using a full collision detection and response-based system, but they found that while it worked great for single frames, it didn’t work well when applied to a whole animation.

In the end, software developer Jeff Chan came up with 2DVD, or two-dimensional volume deformation. Whereas 1DVD controlled the key curves and their offsets from the skin, 2DVD kept track of every feather and the offsets for every CV of that feather. Now, when they created feathers over the entire surface of the groomed bird, they could remember all the offsets of the individual CVs of the feathers, including the extra dimension of the width of the feather. That allowed them to keep the feathers conformed to the skin so they wouldn’t rotate off.

In short, with 2DVD we broke the bond that enforces that the offset be to the same point on the surface. With 1DVD, we are able to remember a specific point on the surface and the offset of the key curve and, with 2DVD, we forget about the specific point on the surface. We simply remember the offset and allow that offset to slide along the surface. Now, if the bird turns its head, the feather actually slides along maintaining its offset but to a different point on the surface, which means the feathers aren’t going to twist. It helps to keep the feathers from interpenetrating each other and results in a much greater level of realism.

—Rob Engle
The last hurdle for the feather team was to ensure that as the birds moved their finger feathers the next level of feathers would move accordingly. The solution turned out to be quite simple. The team used the 1DVD and 2DVD techniques but, rather than applying the offsets from the skin of the bird, they created a lofted surface built from the contours of the primary feathers and applied the offsets from this new surface. The lofted surface would move with the animation of the primary feathers and drive the animation of the feathers on top. Using 2DVD would allow the feathers to slide over each other, while 1DVD would cause the feathers to rotate in the same manner as the primary feathers. This was particularly useful for handling shots in which the wing opened or closed.
Manual Adjustments

A key element of the entire feather pipeline was the ability to manually adjust the results of each of the automated processes. While the feather R&D team created many tools to automate the process of feathering an animation, it was always deemed important that a technical director be able to adjust the behavior of the system at each step. During production, a small team of feather technical directors was responsible for taking completed animation and applying standard feathering tools to the shot. They would then use a variety of manual adjustment techniques (including plucking feathers, manual combing, hand animation and blending static, 1DVD and 2DVD effects) to achieve the final feather settings that would be handed off to the lighter.

In many ways this process was similar to the overall process that cloth technical directors used to create final cloth. They would first use automated techniques (e.g.: cloth simulation) and follow up with manual techniques (including manual animation and blending of results). As a result of this similarity, the SL2 production assigned many of the same people to both tasks, which also resulted in better load balancing of cloth and feather work.
Shading Feathers

A variety of visual effects needed to be simulated using the RenderMan® shading language in order to take the raw geometry generated by the feather instancer and make it appear to be a real feather. Technical director Brian Steiner was responsible for all the shader programming for the birds.

The first and most straightforward effect was to simulate the anisotropic specular effect found with most surfaces (including hair and feathers, of course) in which many features line up in rows. A feather behaves similarly to a section of brushed metal in that the specular highlight will shift as you rotate the feather with respect to a light source.

Another effect that was used, most significantly, on Falcon is a strong specular sheen. In particular, Falcon’s back was difficult to light and keep in a similar range of values with his front because of the strong contrast between these two regions. The addition of the sheen on his back coupled with parameters to control the amount of patterning detail which would appear in the sheen allowed the technical directors to bring the chest and back into similar worlds.

To backlight the feathers, they did an interesting technical cheat. They generated an image of the flight feathers shaded semi-transparent from the point of view of the main camera. The resulting image was more opaque in areas where feathers overlapped. This image was then projected onto the flight feathers for the main beauty pass and used to mix in the backlighting as controlled by a designated light source.
Two different techniques were employed to obtain the different patterning effects on the birds. Procedural controls for Margalo's feather patterning included edge brightness, core brightness and gradation controls along the length and width of the feathers. These pattern controls would allow a technical director to adjust the hue, saturation and value or set specific color multipliers in these different feather regions. Falcon's feathers used all these effects but also incorporated texture maps (derived from hand-painted stencils created for the Henson Company's animatronic) for the large scale patterning on each feather.

Finally, to avoid the “perfect” CG look, Steiner provided a series of controls for edge breakup, splitting and transparency. These effects were layered on top of the detailed hair primitives that made up a feather produced by the feather instancer.

**Falcon’s Feather Regions**

Margalo’s body feathers were very similar in appearance. Most of her feathers could be produced by changing a few major attributes like length and width. The falcon required a more elegant solution to account for his many distinct types of feathers. The Falcon look development team established that Falcon had 29 unique feather shapes and 24 unique feather patterns. Using images provided by The Jim Henson Company, which had built the animatronic, they mapped the falcon body into areas based on these unique shapes and patterns. During the feather generation, this map was used to look up the proper feather attributes needed to generate each specific shape and pattern.
This required an additional step for Falcon. They used all the techniques developed for Margalo, but introduced a region map, which allowed them to define sections of the bird used to specify groups of feathers that shared in common specific parameters. For example, feather regions on the falcon shared color, shape and texturing attributes. This was a much cleaner technique than trying to isolate each region independently over several texture maps controlling the various parameters.

**Summary**

Each bird was feathered by creating about 200 curves around its entire body. Starting with the bird in a static reference position, its wings open, they made it look good in that position and, at that point, figured out for every feather how far each CV was from the surface. As they generated the feathers, they conformed to the shape of these curves. Instead of trying to make every single feather or hair look pretty by hand, using the 200 key curves simplified the process. In the end, Margalo had 3,082 feathers and approximately 70,000 hairs, and Falcon had 3,241 feathers and around 7,000 hairs.
STUART LITTLE 2: Let the Feathers Fly
Digital Clothing
Stuart’s Wardrobe

In approaching the first “Stuart Little,” the challenge was to create Stuart and clothe him. “Stuart Little” was one of the first feature-length films to create CG clothing, certainly the first to create such detailed, tailored costumes in the computer. For “Stuart Little 2,” they already knew they could do cloth, so it was a natural to decide to do even more complicated costumes and more complicated performances with cloth.

In SL2, they created almost twenty different costumes, compared to the first movie’s six or seven costumes. Each of the costumes in this movie have more layers and are more complex, including a raincoat, multiple sweaters, jackets, with such details as little hanging tassels.

All these subtle nuances made Stuart even more believable – and sometimes created problems that needed to be resolved. For example, Stuart has a spelunking outfit that consists of a little rain suit with a big collar. That collar forced the cloth team, led by technical director Doug Yoshida, to figure out how to handle unusual poses. When Stuart puts his arms in the air, where does the collar go? Because he’s also wearing a helmet, they had to create mechanisms to prevent it from running into the collar.

Clothing in SL2 is based on the same basic pipeline used for the first “Stuart Little.” The cloth team started its simulations in Maya Cloth, and then rendered them as several different surfaces in RenderMan®. For “Stuart Little 2,” they created four major enhancements to the cloth tools, including improved shading and rendering.
Once again, though they started with the Maya Cloth plug-in, they didn’t finish their shots there. They wrote tools that smooth out what Maya Cloth generates, and then they created their own “physique” pass, which is based on Stuart’s body pass. Then special smoothing tools ironed out the little wrinkles and problems for each shot. Finally, proprietary rendering tools blended multiple simulations to get the best elements from each one. They had some of these tools on the last film, but the tools were improved to the point that they’re used in every single shot.

Because so much of the film took place in the air, they also created wind tools to add a believable breeze to the final simulation. They also created a tool to animate Stuart’s sweatshirt hood and the little string dangling out of it, to make them look like they’re being affected by wind.

Also new in SL2 is the complex interaction of cloth and Stuart’s body. In one shot, he takes off his robe and underneath are his pajamas, with shirt and pants. They had to make all those multi-layered simulations work, which also required the animation department and cloth department to work very closely together. The animation department mimed Stuart getting undressed and the cloth department worked to make the cloth do what it should do. There was a lot of back-and-forth to make it work.
Stuart also has a great number of accessories in this movie. He’s got a cloth backpack, which he sometimes wears on one shoulder, sometimes on the other, sometimes on both. The cloth team used a combination of more traditional physiquing techniques and clothing techniques to make this backpack.

Clothes are also used quite a bit as props. In one scene, Stuart knocks a blanket off, revealing himself. The gag is that it looks like his head is at one end of the bed when it’s really at the other. Getting this effect to read properly required a lot of interaction between the animation department and the cloth team. Technical director Danielle Plantec made this work as a cloth simulation with lots of hand adjustments to make the blanket part of the performance.

In another shot, Stuart pulls his shirt over his head, balls it up and then kicks it, pretending the shirt is a soccer ball. Technical director Rob House took on the challenge of making the cloth do his bidding. Rolling it up in a ball was especially tricky.
Downstream, the lighters and renderers made the cloth look like real clothing. They spent a lot of time on the shading of the cloth in this movie. Two major shading features they worked on were pilling and edge effects, to make the cloth look not quite new. For the edge effect, the lighter could dial in how bright or dark it was and how much it wrapped around, which made it look like it was catching the light appropriately for each specific scene.

Weave was another shading detail they spent quite a bit of time on. They created many different weaves in the cloth, to differentiate between his khaki pants, his giant T-shirt, his rescue jacket and so on. Because he’s a tiny guy, the weave is a lot more important on him than it would be on a human-sized virtual actor. Because he’s only wearing about four inches of cloth on his whole body, the weave scale is much larger. They tried all different kinds of scales for the weave scale and made an aesthetic choice to fall between being big enough to make him seem small, but not so big that it would swallow him up. Also, if the weave were too big, it couldn’t be seen. Sometimes they adjusted the scale of the weave from shot to shot, depending on whether it shows up too much or not enough. It was less about physics than about aesthetics.
Costumes for the Birds

Early during the design process, they realized that Stuart is clothed all the time, in quite elegant and detailed costumes. It felt a little strange to have Margalo not have any clothes, so they added a helmet and scarf.

They thought they’d create flaps for the helmet’s straps, with the scarf being a couple of flounces. But, because of the inherent dynamic range of motion of her shoulder and neck area, the scarf and helmet constantly collided with each other. While, in the beginning, they solved the scarf interpenetration by hand, eventually Todd Pilger, a senior technical animator, wrote a procedural system that used A/W Maya’s dynamic simulation to drive the chains that drove the flounces. Senior technical animator Yakov Baytler wrote an elaborate script that allowed the scarf to move up and down the neck and be driven by the neck geometry itself.

To solve the problem with the flight helmet’s straps, they put controls in for the straps and then added controls to keep the back of the helmet fairly close to the surface of the head. They didn’t want to burden the animators with that, so they created a small team of people to concentrate on the helmet and scarf.

With Falcon, they also explored costume ideas. At one point, they talked about making him a mob boss character, by giving him a big gold medallion because, after all, he is a collector of shiny objects. It was suggested at one point that maybe the feathers and patterns would form a zoot suit, which didn’t work very well after sketch explorations. So all in all, he’s just himself.

“In an early design drawing, somebody put her in an old-fashioned aviator’s hat and flowing scarf, and everyone really liked the look and feel of it. It defined part of who she is, because she was always supposed to be sort of Amelia Earhart-like, outgoing, very dynamic, adventurous girl.
—Eric Armstrong
STUART LITTLE 2: Let the Feathers Fly

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STUART LITTLE 2: Let the Feathers Fly

CG Environments and Props
Constructing a Digital Skyscraper

After unsuccessfully scouting around New York to find an appropriate skyscraper to be the Pishkin Building, on top of which Falcon has his lair, they decided to build their own – in the computer. They wanted to make it so realistic that people will go to New York and look for it. The Pishkin Building, which shows up in a variety of different angles in almost 50 shots, is huge in scope.

From the beginning, they knew that the building would be featured at various sizes and scopes, which meant it needed to have quite a level of detail. At its highest resolution, the Pishkin Building is very complicated. The Pishkin team, led by CG supervisor Rob Bredow, modelled it at different resolutions: the low resolution has basically no detail except for the basic shapes and the windows; the medium resolution version features quite a bit more detail; and some sections – such as the gargoyle – were at the highest resolutions because they were going to put the camera right on it. Then they painted the building also at various levels of detail. A low-res painting was projected on the whole building, all the way up to a very high level of detail. For any area that was going to get a close-up, texture painters John McGee and Apryl Knobbe painted individual multi-layered textures, with Studio Paint and PhotoShop.
Digital Backlot

They generated a digital backlot for the first time on “Stuart Little 2.” Portions of the Pishkin Building were built on stage. Paul Maurice of LIDAR Services in London laser-scanned a couple of set pieces, including a falcon-like gargoyle that was used as a decorative element on each corner of the top of the Pishkin Building. Meanwhile, senior modeler Marvin Kim built a digital version of the live-action set at full scale.

Six months after the practical version of the Pishkin Building had been torn down, the director decided to modify the look of the gargoyle slightly to accommodate a specific scene. Snowbell, inside a can, rolls down to the edge of the gargoyle’s beak and nearly falls off the building. In the practical set, the gargoyle’s beak was at about a sixty degree angle, which meant there was no way that the can would ever stop. Minkoff thought it would look better if the angle was less extreme. Imageworks was able to implement the change because the Pishkin Building existed in its digital backlot. They were able to tweak the details of the digital building, modifying the slope of the beak to make it more horizontal. Now, the viewer can buy that the can might roll to the end and stop.

Having the Pishkin Building exist as a digital backlot piece allowed the filmmakers the flexibility to change their minds after principal photography was complete and improve the story, without any penalties.
Lighting the Pishkin Building was an unusual experience. The modelers had generated a beautiful still of the top of the Pishkin, rendering it with lots of lights to get a nice, soft look. Everyone loved it, but it was a hugely expensive render. But, since they liked the look of this so much, they wanted to try and achieve it in a way that was more efficient to use in production. Rather than placing 180 lights around the building, they ended up creating a sky dome that mathematically simulates a similar effect.

They decided to treat the whole sky as a big area light. Brian Steiner wrote code to tie Birps, Imageworks’ custom lighting and rendering system, and its interface to RenderMan® into Exluna’s renderer Entropy™, which handles advanced lighting calculations. A beta version of Entropy™ was used which, because it’s a RenderMan®-compliant renderer, easily plugged into the Birps system. With Entropy™, they were able to do the ray tracing required by the model. For example, in one section of the building, there are columns in front of the windows. In a real building, even without sunlight on it, the area behind those columns is going to get a little darker just because of the proximity to the other geometry there. They called this the “ambient occlusion pass,” which referred to the ambient light bouncing around the environment, the light coming from the sky, and the occlusion where that is blocked out.

The importance of the ambient occlusion pass is clear if you look at an image of the Pishkin Building when it’s rendered with a normal key light. There, you see nice highlights where the sun is hitting it straight on and different levels of brightness where the sun isn’t hitting it straight on. But all of the faces of the building that are pointing in the same direction get exactly the same amount of light unless they’re falling in shadow. The result is that it looks very flat.
With the ambient occlusion pass, which is basically a big dome that represents the sky that acts as a light coming from all directions, what you get is areas that don't see all of the sky dome, certain parts of the building that actually block the sky dome from hitting it. The calculations are quite complicated in that the computer has to put itself at every point on the building, look in all directions and see whether it’s hitting building or sky. That’s where the Entropy™ software helped them be more efficient, in that they could render that pass just one time and store it, to use on the building as another texture. It gives the Fishkin Building dimension and a lot more shape.

About ten thousand different pieces of geometry needed to be calculated, so it took a long time. Because the sky is always in the same spot, relative to the building, they only needed to calculate it once. After the precalculation with Entropy™, the actual render was done with RenderMan®. The three major layers are the ambient occlusion pass (or sky dome), the texture pass and the sunlight layer (or key light with its shadows).

Interestingly enough, these three layers (color texture, shadow pass and the ambient occlusion pass) pretty much describe the way a matte painting is built up. In some cases where shots were slated to be matte paintings, they were able to make the matte painting process much more efficient. They generated these three layers and sent them to the matte painting department. The matte artists could then take those three layers and paint touch-ups in any of the three passes and then just combine elements that were given to them, rather than having to paint them from scratch.
The Plane, the Car and the Diamond Ring

Three significant digital props were Stuart’s plane, car and a diamond ring.

The plane is shown in three stages. It starts out brand-new, as Stuart flies it from inside the house into the park. Later, after it’s thrown in the trash, Stuart finds it broken and destroyed on a garbage barge. He reconstructs it with bits and pieces of whatever he finds on the barge and then uses it to escape. Finally, Falcon rips off the top wing.

It was a complicated prop to manage and shade, because it consisted of so many hundreds of little props, wires and gadgets – and it shows up in more than 100 shots in various sizes. In addition, because the plane is often seen close-up, everything needed to be able to hold up to very close inspection. With all of that to consider, the plane’s models, textures and shaders and everything else associated with it took almost 250 GB’s of storage.

When Stuart makes connections to a battery inside the plane, they were required to create a complete digital environment of the plane’s interior, which never existed in a practical form. Art director George Suhayda worked with modeler Ian McLeod to design and realize this digital set. Every element in the shot is digital from the interior walls of the plane to the digital servos, batteries, and wires. George drew a basic design, which Ian roughed in and then, by positioning Stuart in the plane, the composition of the shot, and placement of the various set pieces were then refined through close collaboration between the art and modeling departments.
In the previous movie, a full-scale model was used for Stuart’s car. This time, for convenience on the set, they wanted a CG version of the car that would match the live-action version perfectly. The CG version was used for close-ups, because it was easier than getting a camera into tight spots. That also gave more flexibility in framing. The funny thing is that the live-action car has a lot of plastic on it, and plastic is what rendering generally looks like. When they tried to make the CG car look less “computer-like,” they found it got away from the look of the live-action car.

The remote-control car was used when the car was farther from the camera. They just added a tiny Stuart and Margalo and did not have to worry about lighting and reflections on the car. But they also had a 50-50 version where, if they were going to be at a certain distance, they would take the glass out of the model car’s windshield and replace it with a CG version. That’s because the reflections they got on the set weren’t exactly the reflections they wanted on the windshield. With a CG windshield, they could control the compositing of the windshield over Stuart and Margalo so they didn’t have to try to key them behind the reflections.
The diamond ring, which Margalo steals, is a major prop for an important story point. They couldn’t do a diamond ring without ray tracing, so this was another opportunity to use Exluna’s Entropy™, which was a good solution because it was a lot faster than any of the other solutions tested. They used the ray-traced ring that they had generated and then enhanced it with 2D compositing techniques. Some of those flares and glints coming off of it were actually done as a post process to make the ring look extra shiny and flashy, which also fulfilled another important story point.

**Additional “Unsung” Props**

In “Stuart Little 2,” anything Stuart, Margalo, or Falcon interact with needed to have a digital counterpart.

These are the unsung props and set pieces that will hopefully go completely unnoticed by an audience. For example, when Stuart is seated at a table and chairs, the table, the chairs, the tablecloth, the bowl of oatmeal, the fork, the spoon, the juice glass, and everything else on the table is digital.

When Stuart carries George his glasses, he’s carrying a digital version of George’s glasses. When Stuart is carrying a flashlight and being lowered into the sink drain, he is carrying a digital flashlight and riding on digital hook and string. When Stuart is riding a skateboard, he is riding a digital skateboard.
All-CG Shots

There are more than 100 shots in the film that are completely computer-generated. Many of them are shots of the CG airplane, with the camera tilting up into the sky. The sky was a digital matte painting with multiple layers of clouds and everything moving at different speeds. There are also some all-CG shots on top of the Pishkin Building.

In most of these shots, they took advantage of a system they designed called the “pan and tile system,” which gave the ability to take multiple stills of an environment and tile them all together to form a virtual environment. Bonsai, Imageworks’ proprietary compositing system, has a 3D camera and understands the locations of the tiles in 3D. As a result, there’s really no rendering process; they just place these tiles interactively in the compositing system and work out the camera moves exactly. Or they can import the 3D camera move into the compositing system and let the math put the clouds where they would be appropriately. This was a much more interactive system, and an efficient technique that enabled them to build a large number of all-CG shots.

They didn’t use the pan-and-tile system for all of the all-CG shots. If there were going to be a lot of perspective change or the camera was going to be really close to the objects, the pan-and-tile system wasn’t used. Anytime they did clouds or even buildings that were far away, they could get away with it, but when they were close to the Pishkin, they had no choice but to go with the 3D version.
Putting it all Together
Since “Stuart Little 2” is a hybrid CG/live-action film, all the tasks that place the digital imagery into the real-world were a make-or-break deal for the believability of the characters and their world. That’s what made rotoscoping, matchmoving and compositing much more than just “putting it all together.” Utter perfection was required in these steps to make the digital characters and environments truly come alive.

**Rotoscoping**

Rotoscoping was also a much bigger job on “Stuart Little 2” than on the first film not only due to an increase in the number of shots and the introduction of two more digital characters, but also because of the more complicated action scenes.

The rotoscoping team, as led by Loree Perrett, found that the more challenging sequences were those that featured aerial shots through Central Park. Removing the cranes and cables from the scenes utilized the artists’ entire tool box. Techniques included tracking camera movement using itrack proprietary software, rotoscoping trees and painting the element using Avid Matador® and/or Avid Elastic Reality®. They composited the painted element back into the scene using the proprietary compositing software, Bonsai.

Rotoscoping and paint can occur at any point during the pipeline. While dustbusting, tracking marker removal, and rotoscoping for character placement usually occur at the front end of the pipeline, rotoscoping to isolate areas for special treatment such as color correction, or paint fixes to correct an occasional errant feather typically occur at the end of the pipeline when the shot is in the compositing stage.
3D Matchmoving

3D matchmoving is the job of meticulously matching the (often animated) position, orientation and view of the virtual camera to the camera used to shoot the live-action plates. The purpose of this task is to ensure that a virtual character rendered using this camera will appear to track with any movement of the plate.

The end result, after compositing, is a shot in which the character appears completely integrated into the live-action world. Matchmoving can be particularly challenging because the character interacts with people and objects, while the camera moves around him. Any discrepancy between the virtual camera and the real camera becomes very noticeable.

Since SL2 had three digital main characters and a host of digital environments, such as the Pishkin Building, the film contained approximately 600 3D matchmove shots. Because there were no large-scale models built of the environments in which Stuart lives, all plate photography on SL2 was done on normal scale sets.

The outcome of this was that any small vibration or slide in the physical camera move would yield a large (in Stuart scale) movement of the image. These problems were typically addressed by applying a 2D stabilization pass to almost all plates before being sent to the matchmove department. In extreme cases, if no camera movement was intentional in the shot, a single degrained image of the plate could often be obtained and the subsequent composite would have grain reapplied at the end.
Once the virtual camera move was established, many of the shots required articulate rotomation-style matchmoves in which the artist would painstakingly match the animation of objects with which the characters needed to interact. Most notable are the many shots in which Stuart or Margalo are interacting with the hands of the actors or in which they drive in the practical car model.

Some of the specific challenges unique to SL2 resulted from the characters' small stature. It was very common when Stuart shared the screen with his larger, human co-stars (or for any medium shot, for that matter) that his feet would be visible in the shot. This meant a large number of shots required a high degree of precision because any error in the matchmove made it appear that Stuart was "sliding" - wasn't truly grounded - in the original, live-action plate. In many cases, a 3D matchmove would be augmented with a 2D track to help lock Stuart to the plate. In contrast, the matchmove requirements for shots featuring flying birds or the plane in flight were less stringent due to the absence of actual contact between the virtual and real objects in the scene.

The lion’s share of the scenes used Imageworks’ proprietary Magic Tracker Tool (MTT) system for matchmove tracking. The strength of MTT is that it’s essentially a plug-in to Alias/Wavefront Maya, the same package in which the animators work.

Delivering the final matchmove in Maya avoided potential translation errors. Another tool added later in the production was 2d3’s boujou. While traditionally the matchmovers would rely on modeling and surveying the scene to obtain reference geometry needed for a track, boujou allowed them to efficiently track scenes for which survey information was unavailable. Most notably the matchmovers used boujou for the garbage barge sequence, in which there are a variety of organically shaped objects for which there was no survey information.

Overseeing the efforts of the matchmoving team for SL2 was lead matchmover Jay Banks. Additionally, technical director Rosendo Salazar provided tracking, stabilization and other plate preparation for almost every digital shot in the film.
Compositing

At Sony Pictures Imageworks, a lot of adjustments are made in the composite, as opposed to in the render. Technical directors tweak shadows, get rid of artifacts, adjust edges and do various compositing tricks that help to minimize render times and increase the quality of the final image. Its Technical directors take care of the composites as well as lighting. This has proven more beneficial in the final look of the shots versus having two separate individuals lighting and compositing.

Compositing is used to help integrate characters and props into the practical footage. Stuart for instance, was actually rendered in pieces to prevent fur from penetrating his clothing. Since only his head, hands and tail have fur, these items were rendered separately from all the clothing and shoes. Then in the composite, holdout mattes were made for any layer that had extraneous fur that penetrated the clothes. This also made it easy to color correct each pass separately in the composite. 2D contact shadows were generated to create the illusion that Stuart’s neck fur tucked into his shirt.
They had a similar situation with Margalo, where they wanted to make sure that her feathers weren’t penetrating the helmet or the scarf, which were rendered separately. But because they saw all of Margalo’s body, she was typically rendered as one pass minus the helmet and scarf. This made color correction of Margalo more difficult in the comp, since there were no separate passes of head, feet, or body to manipulate individually. So for Margalo, more corrections were made in the lighting, or extra passes were rendered, color corrected, and then split in with the entire bird.

When a good lighting setup was established for the shot, a composite was quickly rendered on every fourth frame to get an initial sense of the shot. Then the technical directors were able to start in on the compositing finesses such as shadows and other color tweaks to the scene.

**Making It Real**

Regardless of how they want a scene to look, compositors are charged with making the elements they create look like they fit the practical footage they’re given. On SL2, skies were made bluer, trees made greener, rainy days were made to look more cheery, and even the CG characters got a little polish in the composite.

One of the most common techniques for integrating their characters was blurring the edge of their clothing. Light catches the edges of even the smoothest shirt and blends it into its surroundings. Edge softening is very difficult to do in a render but very easy to do in a composite. It’s a very tiny trick, but it has a very dramatic impact on how the cloth looks, because it gives that illusion that Stuart is really wearing something that’s made of threads.
Technical directors also created the depth of field on Stuart like one obtains from a real lens. Every pixel from 3D had Z-depth information that allowed them to selectively increase this blur in the composite. For close-up shots of Stuart in the plane, they could keep Stuart in focus and have a nice gradual defocus to the tail of the plane. This is a common technique, but it has special importance in “Stuart Little 2” because of the scale of the characters. Stuart is a very small character and this technique helps to really sell his perspective.

They made up the term “height of field” to refer to another, similar issue they faced. It was common that, in order to achieve the desired performance, the animators needed to place Stuart in a section of the original image that was out of focus. If the compositor simply tried to match Stuart’s level of blur with the plate, he would have to make Stuart uniformly out of focus. The solution was to fade off the blur over Stuart’s height such that he would be sharp around his face, yet his feet would match the plate. While this effect would never appear in the physical world, it was a necessary cheat to integrate him in the plate.

Diffusion was added on many shots that still appeared too crisp or sharp. CGI is inherently resolute, and often times too sharp for the plate with which it’s integrated. Subtle diffusions were created by blurring, fading, and adding the same element back on top of itself. They added diffusion to numerous shots where Stuart and Margalo are fighting Falcon in the sky. Because these were very strong sunlight shots, diffusion helped integrate the CG into the plate.
There were also instances of blooming and flaring that they created. Blooming is when a light behind an object gets so bright that it appears to eat into the edge of the foreground object and flaring occurs with highlights spreading beyond the source like a star filter. They bloomed the highlights in shots like Stuart driving his car down the street in daylight. The glints off the chrome windshield frame helped to integrate the CG car. And Mrs. Little’s ring used the same flaring technique; they took the specular component, blurred it and added it back in the composite. An example is the blooming on the Falcon when he passes in front of the sun.

**Shadows**

Technical directors typically created three shadows for each character on the ground, a cast, a contact and a “sausage” shadow. Successful integration of these three types of shadows created a truly realistic character shadow.

First a tight contact shadow of just the feet was rendered to emulate the very dense shadow an object creates when it approaches a surface. Then, the “sausage” shadow was rendered or rotoscoped to create a general darkening at the base of the character. And finally, the cast shadow was blurred in the composite to appear sharp at the feet and defocused as it moved farther from the character. If a cast shadow fell across something other than a flat plane, the compositor would warp the shadow to match the bumps and curves of whatever Stuart was standing on. Even more difficult was matching existing shadows from Snowbell, the cat, when they crossed over the CGI shadows. In this case, intricate luminance matte pulls from the plate were generated to seamlessly combine practical and CGI shadows into the final image.
Multiplaning of Matte Paintings

In scenes where Stuart and Margalo are flying around in the plane, the sky was a CG matte painting. The matte painting department delivered oversized layers of clouds, sky and land which were positionally animated in the composite. Compositors synthesized these layers with motion blur to achieve the effect that the camera was moving through space with the characters. The judicious use of lens distortion helped sell that the image originated in the physical world.

Bonsai and Other Tools

Imageworks’ in-house compositing tool is Bonsai, a node-based compositing package that runs the typical gamut from blue screen pulls to grain for specific film stocks. But it also adds some 2D/3D features like pan and tile which allow artists to import Maya image planes and stitch them together for a seamless 3D world, which can then be manipulated in the composite. They also benefitted from an in-house command line compositing tool for simple tasks and a proprietary 2D tracking software for stabilizations.
Improving the Pipeline

The biggest facility-level change in producing “Stuart Little 2” was the introduction of the Linux render farm. As opposed to buying a comparatively expensive workstation, they were able to buy relatively inexpensive, very fast processors with lots of memory. They initially bought 200 processors and, when these proved successful, ended up with nearly 600 processors. Introducing Linux rendering meant that they had to build software and tools to work equally well – and achieve identical results - on Linux and Irix. Significant work by the software and production pipeline groups enabled that to happen.

The other big benefit that they achieved on SL2 was in moving to RenderMan® 3.9. In that release, Pixar made some significant improvements in the performance of rendering curve primitives, and also in dealing with semi-transparent objects. Previously, with semi-transparent hair tips, the addition of layers through transparency tended to slow down RenderMan® renders.

These changes saved a great deal of time. With improvements, in particular with the introduction of opacity threshold, RenderMan® 3.9 offered a great deal of speed improvement, up to 30 percent. Linux gave about one-quarter to one-half of the render time that they were getting on their fastest Irix box.

These changes had a tremendously positive impact on the production flow. Linux was also used for net-rendering, when somebody needed to do an interactive render. They still are not at the point where they’re using Linux on the desktop, but that is a trend that will ultimately take Imageworks in that direction.
Digital Finish

The concept of a digital finish on “Stuart Little 2” has been championed from the start by Steven Poster, ASC, who was the cinematographer on the film. His idea was to use advanced color correction and tracking tools normally limited in their use to the video and DVD release of a picture for the initial theatrical release of this movie. A digital finish would help enhance the look of the picture and address standard production problems. Day exterior scenes shot over several days that were both sunny and cloudy could be manipulated with these tools to create a more consistent look. Color saturation and contrast could be addressed in a manner that is unavailable utilizing the photochemical process.
Certain specific elements of SL2 made it the perfect candidate for a digital finish. Sixty-five to seventy percent of the movie contained CG imagery and already existed as digital files. That reduced the amount of non-effects scanning and dust busting required. All shots, both effects and non-effects, would be scanned and film recorded in the same generational state. This would provide a seamless look to all the shots, regardless of whether they were effects or non-effects shots.

The development of a digital intermediate business at Sony Pictures Imageworks has been spearheaded by John Nicolard, vice president of technical film services. There were several reasons for establishing this service. The first was the abovementioned capability of enhancing the look of the pictures for which Imageworks provides effects work. Second was the ability to provide an all-digital finish for in-house Imageworks productions. Finally, Imageworks could provide this service to Sony Pictures Entertainment on pictures being prepared for digital exhibition. The concept was to create the highest quality product possible in the digital realm.

The Imageworks idea for digital intermediate was working in Cineon space, with pin registered, full bandwidth RGB 4k scans that were scaled to 2k. Imageworks’ Imagica scanners were utilized for this function. This route would yield higher quality scans than non-pin registered, lower resolution telecine style scanners could provide. In addition, all material in the picture would be scanned this way and digitally assembled in Cineon space. This would keep all shots in the same generation and alleviate the need for scanning from a cut negative. Color correction would occur in Cineon space with no color space conversions of any data required.

The digital assembly process was first tested by Imageworks on “Spider-Man.” Thirty minutes of effects and non-effects material was assembled for specialized color correction. The pipeline was modified for SL2 based on that experience. The task was to fine-tune the assembly and dustbusting process and to incorporate color correction into the process, which included building a digital screening room.

Mike Wilson, lead engineer of Imageworks’ systems and data base group, wrote specific code to facilitate the automation of the digital assembly. The Avid EDL was referenced to all on-line scans and Mike’s code assembled the data in accordance with the EDL. Imageworks senior systems engineer Dan Lake played the lead role in facilitating the dustbusting pipeline. Data was accessed from network storage, dustbusted using Matador, and then returned to network storage. In addition, each shot was versioned to indicate that it had been dustbusted.

Imageworks’ technical manager Anthony Ceccomancini wrangled I/O of the edited data through the color correction process using 5D’s Colossus, and Poster, Nicolard and Jerome Chen supervised colorist Mike Eaves in preparing the color. A Barco D-Cine Premiere DP50 digital projector was then used to project the image in Imageworks’ screening room for approval by Rob Minkoff. Finally, the data was recorded onto Eastman Kodak 5242 intermediate film stock using Imageworks’ ARRILASER film recorders.
My concept when I got the job, and after first talking to the director Rob Minkoff, was to do a digital finish. By the time the movie was finished and half-edited, everyone was on-board with the idea. In my mind, the reason it needed to be done that way was that 60 to 70 percent of the movie was being scanned anyway. To go back to film and then combine it as a film print seemed totally counter-productive.

Also, whereas the first film had no sun in it, this was going to be a sunny film. The emotional swing of this movie was entirely different, and we wanted to tell that story with light and color. We knew that we had to play with the color palette in a way that wouldn’t have been afforded to us with a straight film finish.

I felt that by the time we’d be ready to make this print, the process of digital intermediate would have come of age - and in fact it has.

—Steven Poster, ASC
STUART LITTLE 2: Let the Feathers Fly

Course # 32, SIGGRAPH 2002
San Antonio, TX, USA

STUART LITTLE 2: Let the Feathers Fly

Parting Shots
Conclusion

“Stuart Little 2” was an unusual, demanding and ultimately satisfying experience for the more than 100 Imageworks visual and technical artists who worked on it. Everyone at Imageworks felt that they were blazing new trails with their work on the film. Instead of the more typical challenges found in visual effects movies, they were embarking on creating a new kind of effects film, a hybrid of believable digital character animation and live-action photography. As pioneers, they were all winging it, so to speak, in that they couldn’t rely on the work of anyone who had gone before. It made it refreshing…and a little terrifying.

But the sense that they were working on something really different, really groundbreaking, kept everyone’s spirits up in the air, as they brought these three characters to life. Stuart, Margalo and Falcon were all very real and alive to them, and the results of their work will make these characters all very alive and charming for audiences.
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A Bit of Hindsight From the Supervisor

When “Stuart Little 2” delivers its final digital frame to production editorial, I will have been on this project – including the first “Stuart” movie - for almost five years. At Imageworks I am not alone in this fact. Many others have been on this road with me. I doubt that anyone not directly involved could understand just how much more difficult SL2 was than the first Stuart movie.

The challenge of SL2 was conceptually simple: create three synthetic main characters, who have more than an hour of screen time, in a hybrid CG/live-action feature film. The heart of the reason for creating SL2 lies in a conversation I had with director Rob Minkoff, who said “The only reason to do this one is to make it better than the first.” It was clear to me then that this sequel was not meant to be a shadow of the first: it had to shine brighter. The characters had to look better, the animation had to be more engaging, the overall quality was meant to surpass the first groundbreaking film.

The task of realizing the concept at Imageworks required two years of work from more than two hundred people. At least half of those people worked longer than ten hours a day for a year straight, some even on weekends. It is easy for me to see the evidence of that kind of dedication and discipline: it shows itself quite plainly on the big screen, in the visages of Stuart, Margalo and Falcon.

There is nothing more satisfying for a visual effects artist than to create an image which you are quite certain has never been seen before. I can only hope, after the pain of production has passed, that the artists and animators working on our show understand that they have created memorable film characters.

A complicated production entity like the SL2 visual effects crew at Imageworks requires a military-like level of organization, in terms of hierarchy and regimented areas of responsibilities. Jay Redd, my co-supervisor, partnered with me to define the creative goals of the show. His sense of artistry is a trademark on every shot of the show. Michelle Murdocca and Jody Echegaray, veterans from the first “Stuart” project, managed a visual effects and animation budget larger than most budgets allocated for an entire live-action film. They nurtured the creative environment in which we created many wonderful images. Brian Keeney produced a new area of production for us on SL2, the challenging creation of talking cats. These producers were supported by a cadre of disciplined coordinators (Maureen Beatty, Katherine Concepcion, Mark Fletcher, Mickey Levy, David Orecklin, Pia Turchyn, Eric Withee and Julie Zackary) who noted on their laptops every utterance at every meeting that took place over the course of two years (just imagine) and tracked the progress of thousands of tasks. To follow the military analogy, Michelle’s team consisted of the strategists and logistical support personnel for SL2.

On the tactical front were Erik Muenker and Kerry Shea, our digital production managers. Erik managed shot production on a daily basis, balancing throughput within the parameters of
a fixed amount of rendering and disk resources. Kerry managed the matchmoving and animation-oriented assets to insure that each shot had what was required to proceed to final lighting and compositing. They were our field marshals.

Right on the front lines were our stalwart CG supervisors: Rob Bredow, Rob Engle, Layne Friedman, Thomas Hollier, Sean Phillips, Sean Schur and Pete Travers. Their responsibilities were enormous, supervising and coordinating their individual teams of artists in an effort to reach the level of quality desired by Jay and myself. They did not fail once. In reaching that level they pushed a crew of talented artists to the leading edge of digital imagery.

The heart of our film comes from the animation of Stuart, Margalo and Falcon. Our trio of synthetic characters would not have life without Tony Bancroft and Eric Armstrong, our animation supervisors. Along with animation producer Melissa Kurtz and production manager Lauren Littleton, Tony and Eric oversaw the forty-strong character animation crew that gave Stuart, Margalo and Falcon their memorable performances. Notable are the lead animators, Paul Jessel, Kenn McDonald, Sean Mullen, David Schaub, Chad Stewart and Todd Wilderman. Their work is an amazing thing to watch.

Everyone should realize that certain artists toiled with pencil and paper long before anyone sat at a workstation and created a Maya file. I was there when Rob Minkoff drew his first sketches for Margalo (which became the basis for the final character) but I feel that the inspiration for her personality really came from an earlier illustration by animator Todd Wilderman. Henry Darnell defined Margalo dimensionally with his clay sculpture of her (which was eventually digitized into 3D). These birthing moments, using the traditional arts, created the foundation on which many revolutionary digital tools were built.

Falcon and Margalo are very sophisticated CG creations, requiring an impressive level of artistic and technical talent. The software team that created our feather technology consisted of Armin Bruderlin, Gokhan Kisacikoglu and Jeff Chan. When it came time to build the characters in CG, Henry Darnell and Kevin Hudson digitally modeled Margalo and Falcon (along with dozens of other objects for the film). The look development of the feathered characters was pioneered by artists like Virginia Bowman, Bob Winter, Chris Yee, Brian Steiner and John McGee. They groomed, shaded and painted every feather on Margalo and Falcon’s head and body. The animation set-up for the characters was handled by Aaron Campbell, Chris Waegner and John McLaughlin.

An important contributor to creating the reality of Stuart’s Manhattan was Ivo Horvat and his digital matte painting team. Their work was present in over a hundred shots in the form of Central Park backgrounds and the wonderful sky and cloud paintings, which have been deemed “the fourth digital character” in the film.

Under George Suhayda’s direction, the art department was instrumental in designing many aspects of the Stuart world, particularly his vehicles; Michael Scheffe’s talents were seen in Stuart’s biplane and John Bevelheimer penned the shape for Stuart’s new roadster.
John Berri and Shannon Leigh Olds managed the editorial team responsible for processing the tens of thousands of takes we generated and the numerous changes handed down from the production. Todd Hara led the team of technical assistants with the enormous task of managing all of our digital resources and data.

Many of the contributors to a project like SL2 rarely receive proper recognition for their efforts, but in a pallid attempt I will at least list the many kinds of talents we relied upon on a daily basis: shader writers, lighting/compositing artists, previsualization and conceptual artists, effects and character animators, character modelers and physiquers, animation support, texture and matte painters, feather and cloth technical directors, matchmovers, roto artists, technical assistants and software engineers. Essential departments like editorial, scanning and recording, digital color timing, software, systems support, research and development, facilities management and our executive staff were reliably present to provide the show with everything necessary for such an endeavor in state-of-the-art visual effects and animation.

The only thing I can offer for everyone’s efforts is a simple, but heartfelt: Thank you.

[Signature]
STUART LITTLE 2: Let the Feathers Fly

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