Course #14, SIGGRAPH 2000
New Orleans, LA, USA

Stuart Little: A Tale of Fur, Costumes, Performance, and Integration: *Breathing Real Life Into a Digital Character*

Organizers:
Jim Berney
Jay K. Redd

Presenters:
Henry F. Anderson III
Jim Berney
Jerome Chen
John Dykstra
Jay K. Redd
Scott Stokdyk

Sony Pictures Imageworks, Culver City, CA

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Presenter Biographies

Jay K. Redd
Senior CG Supervisor
Sony Pictures Imageworks — contact poko@imageworks.com

Functioning as a Senior Computer Graphics Supervisor on Columbia Picture's "Stuart Little", Jay started his involvement with the feature in the early days of pre-production and character design, and lending co-supervision to the technical and aesthetic research and development for the films' extensive hair and fur, and co-supervising the lighting requirements. As an amateur astronomer, he animated and supervised "Contact's" Opening Shot, a 4,710-frame journey from earth to the end of the universe, which has received many international awards.

Before joining Imageworks, Jay spent four years at Rhythm & Hues Studios working as a Technical Director and then Computer Graphics Supervisor on numerous features, commercials, and theme-park rides, including the Academy Award® Winning "Babe", and the award-winning Seafari. He is in involved with L.A.'s independent film-making community. Jay studied at the University of Utah with an emphasis in film, music composition, and Japanese. Jay has lectured and presented all around the world, including The London Effects and Animation Festival, Germany's FMX Digital Media Festival, the Australian Effects and Animation Festival, SIGGRAPH 1999, the Museum of Television and Radio, UCLA Extension, Visual Effects Society programs, World Animation Celebration, and numerous other schools, festivals, and competitions. His projects thus far seem to have a running theme of space and animals.

Film Credits: "Stuart Little", "Contact", "Sphere", "Babe", "Kazaam", "Waterworld", "Seafari"

Jim Berney
Senior CG Supervisor
Sony Pictures Imageworks — contact jimb@imageworks.com

Jim Berney is a staff member of the Sony Pictures Imageworks Digital Production team and Senior Computer Graphics Supervisor. He provides technical direction for production modeling, texturing, and lighting pipelines. Mr. Berney joined Imageworks in 1996 from MetroLight, where he was a Research Technical Director and part of the Software Development team, authoring flocking software for "Batman Forever" and procedural natural phenomenon lighting software for "Undersiege 2" and "Mortal Combat".

Mr. Berney received his Master's degree in Computer Science from California Polytechnic, San Luis Obispo, specializing in the research and development of a new global illumination paradigm. He holds two undergraduate degrees in Computer Science and Economics from the University of California, Irvine, focusing in AI Research for NASA under the guidance of Pat Langely. Jim also studied computer architectures at the Royal Institute of Technology, Stockholm, Sweden. After graduation, Jim worked 3 years for DARPA as an ADA programmer for a large software-engineering consortium.

At Imageworks, Jim served as CG Supervisor on the feature film "Stuart Little" and was involved in the beginning stages of developing the costuming technology which enabled the design, building, and simulation of 13 costumes for three CG characters.

Jim also supervised the development of the versioning and publishing system and co-supervised the development of the lighting pipeline that facilitated the seamless integration of the Stuart Little character into live action scenes.

Prior to “Stuart Little”, Jim served as CG Supervisor on the feature films: “Godzilla”, and lighting lead on “Contact”, “Starship Troopers”, and “Anaconda” where he developed rendering tools and the pipeline for photo-realistic lighting techniques.

Jim’s research interests are in the area of global illumination, artificial intelligence, neural networks, and version and publishing. Jim has published IEEE articles, and presented at various local festivals, including SIGGRAPH and Visual Effects Society gatherings.

John Dykstra
Senior Visual Effects Supervisor

Visual effects wizard John Dykstra won a Visual Effects Academy Award® for his work on *Star Wars* as well as an Academy Technical Achievement Award® for Industrial Light and Magic. Dykstra was instrumental in the founding of the now world renowned Industrial Light and Magic with Gary Kurtz and George Lucas.

John arranged the creative team to design and builds the *Star Wars* miniatures and camera systems.

Dykstra came to the entertainment industry with a background in industrial design and still photography. In his early days he worked building models and doing effects photography, as well as designing, building, and operating a computer controlled camera system for the National Science Foundation at UC Berkeley. This sophisticated camera would later be acknowledged as the foundation of motion control technology. Dykstra went on to produce and serve as visual effects supervisor on *Battlestar Galactica* working with his key creative team from *Star Wars* in there newly formed company, Apogee. Using Apple’s first personal computers as the basis for its motion imaging systems, Apogee garnered an Emmy from their *Battlestar Galactica* work.

While at Apogee, Dykstra’s effects team captured an Academy Award nomination for *Star Trek: The Movie*. Dykstra continued contributing to visual effects for many feature films, entertainment theme parks, video games, as well as directing commercials. Under Dykstra’s guidance, Apogee developed benchmark motion control and blue screen technologies.

Most recently Dykstra was visual effects supervisor on *Batman Foreve*r and *Batman and Robin*. He joined Imageworks in March 1998 to supervise visual effects and direct second unit for *Stuart Little*, which was recently nominated for an Academy Award®.

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(Presenter Biographies continued)

Jerome Chen
Visual Effects Supervisor
Sony Pictures Imageworks

Jerome Chen combines an artistic approach with technical savvy to become one of the motion picture industries most innovative visual effect supervisors.

He joined Imageworks shortly after its inception in 1992 and worked his way up through the production ranks as a Digital Artist, going on to become a Senior Animator, Senior Technical Designer, Computer Graphics Supervisor and now Visual Effects Supervisor.

His credits include “Stuart Little”, “Godzilla”, “Contact”, “James and the Giant Peach”, “Phenomenon”, “The Ghost and The Darkness” and “In the Line of Fire”.

An acknowledged expert in the technique of integrating live action with digital elements, Chen taught a digital compositing course at SIGGRAPH computer graphics conference with Ron Brinkmann.

He has also been a guest speaker at the UCLA Computer Animation graduate program. Prior to joining Imageworks, Jerome worked as a 3D and paint-box artist at various post-production houses on both the east and west coasts. Jerome studied visual arts and English literature at the University of Maryland at CollegePark.

He has been nominated for an Academy Award® most recently for “Stuart Little”.

Scott Stokdyk
Senior CG Supervisor
Sony Pictures Imageworks

As one of the CG Supervisors on “Stuart Little”, Scott focused on the character and animation setup pipeline, while also supervising multi-character shots in many different sequences. In addition, he helped develop and lead the effects work and created various composite setups that were used on Stuart elements.

While at Imageworks, Scott has contributed to “Contact”, “Starship Troopers”, “As Good as it Gets”, “Godzilla”, “Stuart Little”, and currently “The Hollow Man”.

Prior to that, he was employed at Digital Domain where he worked on “Fifth Element” and “Terminator 2-3D”, and did some early R & D on “Titanic”.

Other work at previous employers (Metrolight and MotionWorks) includes “Broken Arrow”, a Herbie Hancock music video, an AMC theater spot, and various commercials.

Scott received his B.S. and M.S. in engineering at Harvey Mudd College, where he led student projects for Qualcomm and Hewlett Packard, including an anti-aliasing research study.

Scott has presented at SIGGRAPH, Visual Effects Society gatherings and other venues, including user groups, effects festivals, and international competitions.

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Henry F. Anderson III
Animation Director

A graduate of California Institute of the Arts character animation program, Henry F. Anderson III has worked as a director of digital character animation for the past 10 years. His specialty is creating convincing, believable digital actors.

He has directed projects at Pacific Data Images (PDI), Rhythm&Hues, Pixar, Digital Domain, Blue Sky, and now Sony Pictures Imageworks.

These have included both all animated projects as well as live action/animation combinations. He has been responsible for creating the performance of several digitally animated “spokes characters” for national and international campaigns, including the Polar Bears for Coca-Cola.

In addition to several Clio Awards, Henry won a Prime Time Emmy for “The Last Halloween”, a CBS/Hanna-Barbera special which was the first television production to feature digital lead characters within a live action show. The creation of Romtu, Gleep, Scoota, and Bing, the four Martians who visit Earth on Halloween night in search of candy, was a milestone in animation.

Outside of his directing assignments, Henry has taught character design at Cal Arts and has given talks and presentations about digital character animation in North and South America, in Europe, and in Asia.

Henry was also panelist on the SIGGRAPH 99 Special Session “Animation...Then and Now”, and was most recently nominated for an Academy Award® for “Stuart Little”.

Before attending Cal Arts, Henry studied biology at UC San Diego where he worked with lots and lots of mice.

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(subject to change without notice – times are approximate)

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B. Concept and History of Stuart Little
  Early ideas, requirements, scope of production (20 min) **John Dykstra**
  Who is Stuart Little? (15 min) **Henry Anderson**
C. Research and Development: The how's and why's
  Look development (40 min) **Jay Redd**
    -modeling and character design
    -fur wet/dry, skin, texturing
    -shading and lighting development
    -rendering methods, procedural generation of geometry
    -handling multiple characters
  Costuming (40 min) **Jim Berney**
    -patterns and tailoring
    -cloth dynamics
    -shading and lighting development
    -element/data tracking: versioning and publishing
  Character set-up, 2D integration, CG effects (40 min) **Scott Stokdyk**
    -matchmoving, set tracking, motion matching
    -character facial expressions
    -character set-up, physiqueing, animation tools
    -CG effects and live-action integration methods
D. Stuart's 'Screen Test' (15 min) **Jerome Chen**
  Bringing it all together
    -plate photography
    -implementing new tools
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E. Discussion, questions and answers (15 min) **All**

-LUNCH BREAK- (1.5 hrs)

F. The Heart of the Production
  Physical effects vs. CG effects (30 min) **John Dykstra**
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  Giving Stuart life through acting and animation (30 min) **Henry Anderson**
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    -breaking the 'That's an effect...' barrier
G. Stuart's real-world: Case Studies: Shot breakdown
    The Boat Race, multiple costumes, shading (20 min) **Jim Berney**
    Central Park, the Stouts, lighting, wet/windy fur (20 min) **Jay Redd**
    Washing Machine, Finds House, compositing, effects (20 min) **Scott Stokdyk**
H. 'Lost Footage' (5 min)
I. Discussion, questions and answers (25 min) All
J. Close (5 min) Jay Redd/Jim Berney
    -the future of digital characters
    -new and emerging technologies

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Stuart Little: A Tale of Fur, Costumes, Performance, and Integration:
Breathing Real Life Into a Digital Character

Introduction

Jay K. Redd
Sony Pictures Imageworks, Culver City, CA

Introduction to "Stuart Little"

When all was completed, Stuart Little was a feature film with over 600 shots that contained some sort of visual effect - a talking cat, digital mouse, rig removal, etc. While we've all witnessed films with dazzling effects since the medium was even invented, the simplest thing that sets "Stuart Little" apart from other 'effects films' is Stuart Little *himself*. He is not a dinosaur. He is not an alien. He doesn't carry a laser pistol (at least that we know about). If the audience can sustain the disbelief that there is a mouse walking around on two feet, wearing clothes, and talking, then Stuart Little is indeed real. If the audience forgets that Stuart is a completely digital effect, our job as artists and technicians is well done. However, if for one second, the audience loses their connection to Stuart because of some digital artifact or inaccuracy, our job has failed.

Stuart has and continues to wow audiences around the world, through his charms, his good looks, his acting, his costumes, and most of all, his character. It's Stuart's character that drove everyone to make this film and to bring us this far, even this far to write notes for a SIGGRAPH Course. Stuart's character touches the hearts of millions of people around the world. With all the dazzling advancements in technology, the real-looking cloth and costumes, the real-looking fur, the real-looking talking cats, and the adventurous boat race, the film simply wouldn't be a good film were it not for the 'character' of Stuart Little. The word 'character' is described in the dictionary as:

char•ac•ter n. –
1. The combination of qualities or features that distinguishes one person, group, or thing from another.
2. Moral or ethical strength
3. A description of a person's, or mouse's attributes, traits, or abilities.
4. A notable or well-known person or mouse.
5. A person, or mouse, esp. one who is peculiar or eccentric.
6. A person, or mouse, portrayed in an artistic piece, such as a novel or film.
7. Stuart Little. (how'd that get in there?)

Many visual effect artists have an old credo: *The effect should support the story* (it's too bad that more films don't support this way of thinking). The challenge of Stuart Little was both daunting and enticing, as the lead character could be realized only through special visual effects. As the lead, Stuart had to be more than a quick sustained illusion meant to enhance the story. He wasn't going to be talked about for 90 minutes, only to show up in the last six climactic scenes of the film. He needed to show feelings, emotion, reaction, anger, love, fear, etc.

He needed to be engaging and convincing enough to draw the audience into the very heart and soul of the film. He *was* and *is* the story.

In his book and in his film, the definition of 'character' holds 100% true for Stuart Little. It's why the film is magical, and why the entire film crew spent months and years inventing new technologies, production practices, and collaborating on this film. While his fur, cloth, and performance are individually wonderful, these things simply help create the 'character' of Stuart Little.

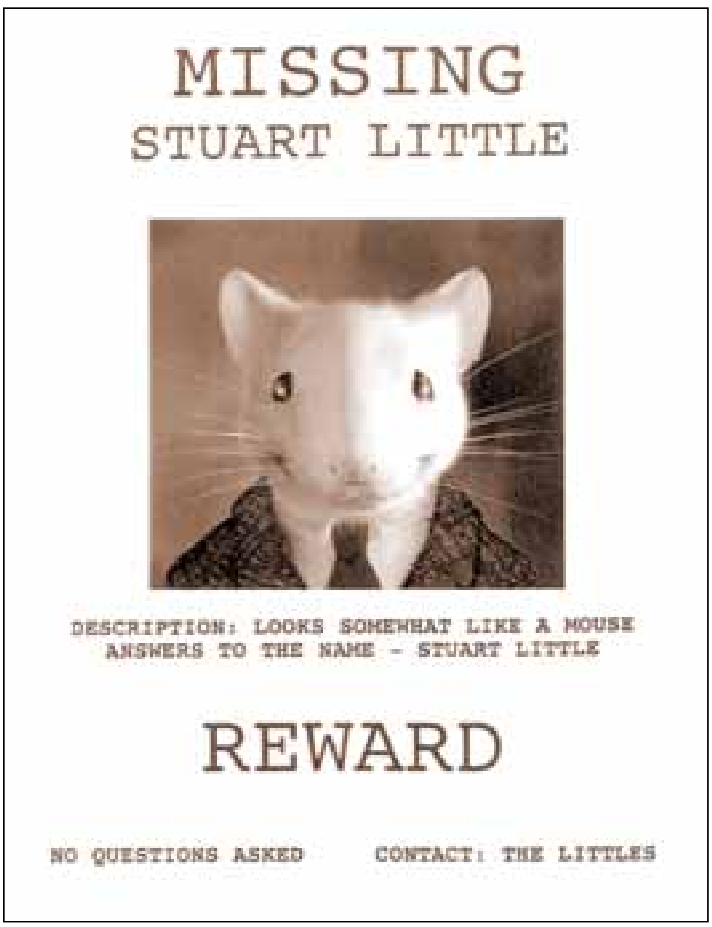
The audience must believe that a real mouse could have been taught to act and wear costumes. They need to believe that when the director yells "cut", Stuart walks off the set along with Geena Davis and Hugh Laurie, to their trailers to study their lines and prepare for the next scene.

Course Note Structure

The following course notes will cover the entire process of the making of this film. While this course is intended and aimed for a graphics and technically oriented audience, the notes will often times touch on other subjects, or perhaps even discuss things that might not at all appear related to the field of graphics and graphics development. This is entirely intentional. In making this film, computers and computer graphics touched almost every single aspect of the production. For this film, the computers simply became a tool used by the actual human beings to create a living, breathing, digital character.

If you walk away after reading these course notes with only one thing, it's that *real people* made this film. The crew and artists who were a part of Stuart Little are all geniuses in their own right. So often in media, particularly when visual effects or computer graphics are concerned, what gets mentioned is 'the computer'. Without the person sitting behind a computer, a camera, or a backhoe, all that exists is a cold lifeless piece of machinery.

For Stuart Little, actual human beings used their heart, their soul, and some cold lifeless machinery, to create an unforgettable and groundbreaking character named Stuart Little. These course notes are theirs, and they are also Stuart's history. As Stuart himself says "It's like a fairy tale."

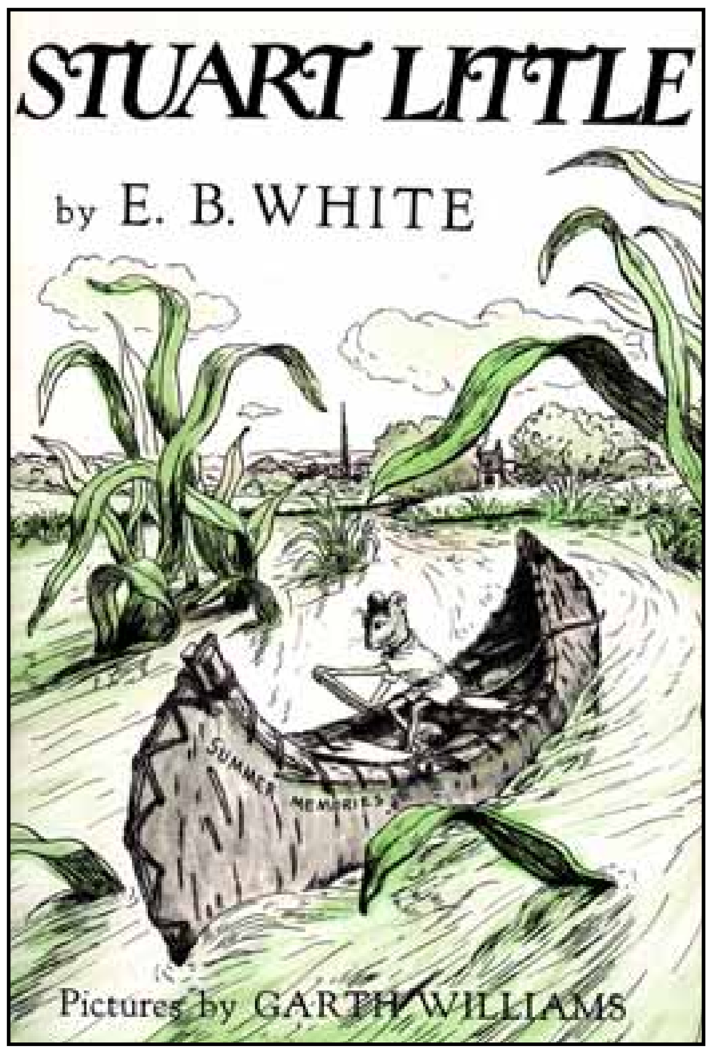


The Birth of 'Stuart Little'

Over two years ago, Tim Sarnoff, the general manager of Imageworks, came back from a lunch with one of the studio executives at Sony Pictures and convened a few supervisors and in-house directors for a hasty meeting. "Could we create a convincing, fully clothed and verbally articulate mouse with human qualities to star in a motion picture based on the E.B. White classic, "Stuart Little"?" he asked.

While Sony Pictures Imageworks had a reputation of producing amazing digital images for films such as "Contact", "Godzilla", "Anaconda", and "Starship Troopers", its character animation work, while rewarded with accolades that include two World Animation Celebration Awards, had yet to be tested under the rigors and details of the size and scale of the proposed Stuart Little.

Digital actors have existed for a few years now in many films like "Toy Story," and some outstanding characters populate the history of film, and memorable 2D performers are brought to animated life on screen. However, in the realm of photo-realism, the accomplishments have been more spectacular in the realm of fantasy — the amazing dinosaurs in "Jurassic Park," giant lizards, dragons, chrome-metal men, and apes or alien creatures, that while breathtaking and amazing, bear no relationship to real life as we know it. Imageworks was being asked to create a fully digital movie star, capable of delivering a performance that would carry an entire movie. He had to look like a mouse, and everyone knows what mice look like...and he would have to look real in a live action world, as if he really belonged there. Going beyond *photo-realism*, and achieving *photo-real* — this was a subtle but very distinct and difficult task. This would be an extraordinary achievement — if it could even be done.



Actually, Tim had already said 'yes' to the studio. The mountain of R&D ahead didn't stop Sarnoff from recognizing a great opportunity when he realized Columbia Pictures' interest in bringing Stuart Little to the big screen. The magic of Stuart Little was clearly dependent upon the character's realism and performance, and Tim was determined to make this dream come true, even if no one yet had created a photo-real *CG* ***lead*** *star* for a live action film.

Tim knew the talent existed to make this happen. Perhaps the biggest question was whether or not the technology would support a photo-real character.

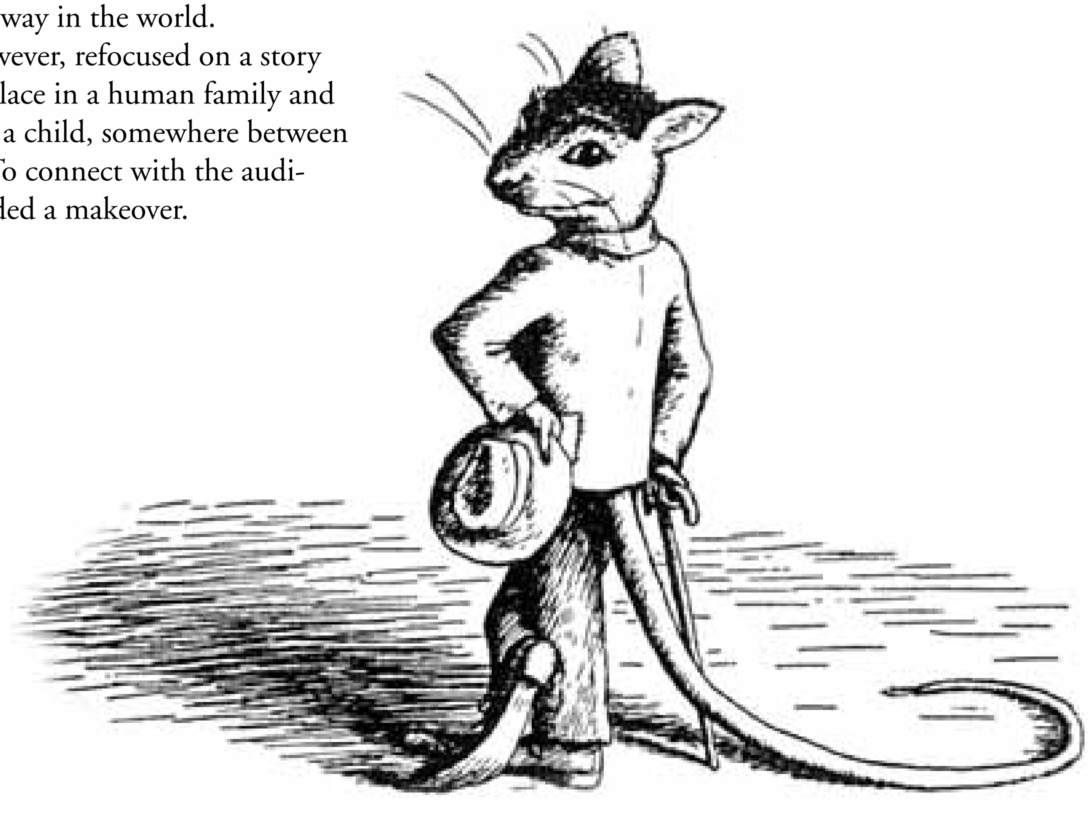
Meanwhile, there were other things other people were worrying about.

Character Design

Perhaps the largest amount of time spent on any film, character based or not, is the *design* phase. For Stuart Little, this meant the design of the character first, before anything else. Other parts of a film that go through this phase are the sets, the costumes, the lighting, the story, the entire production process, etc. Again, since Stuart Little the mouse is the driving force behind this movie getting made in the first place, the greatest amount of attention is paid to him. After all, he is the leading man, er...mouse.

In 1945, artist Garth Williams made the first drawing of Stuart Little, as seen below. He drew Stuart much the way E.B. White had described him in his book, as a tiny guy with a lot of mouse-like qualities. As fashion of the times, Stuart donned a fedora and often dressed in three-piece suits. He was a rather dapper little fellow who bore a strong resemblance to his creator, the urbane New Yorker E.B. White. Williams' original drawings of Stuart as sophisticated worked well, because in the original story, Stuart ages to manhood (mousehood?) and leaves home to find his own way in the world.

The movie version, however, refocused on a story about a mouse that finds a place in a human family and on the character of Stuart as a child, somewhere between the ages of seven and nine. To connect with the audiences of the 90's, Stuart needed a makeover.



Since it was determined the movie would use state-of-the-art technology and computer animation, the point was to make Stuart as real as possible so that again, the audience would think it was a real mouse that could act, talk, walk, and connect. For this connection to take place, simple but very important questions arose and needed to be answered:

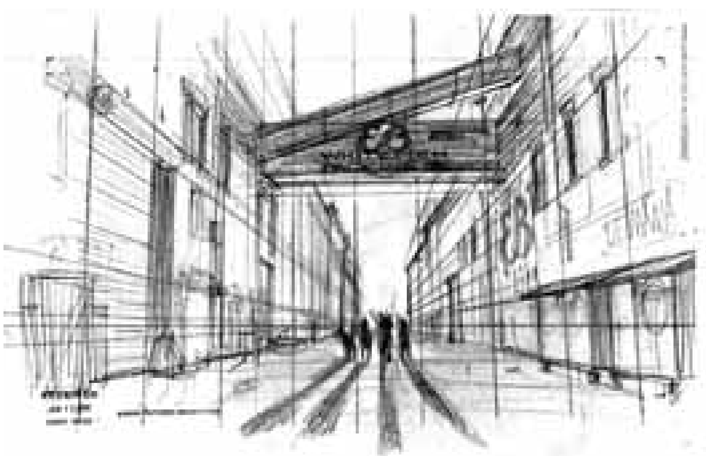
- what would he look like?
- more mouse-like or more like a boy?
- how tall would he be?
- what would his hands look like?
- would he walk on all fours or walk on two legs?
- what kind of clothes would he wear?
- what would his fur look like?
- would he interact with others?
- what makes 'cute'?

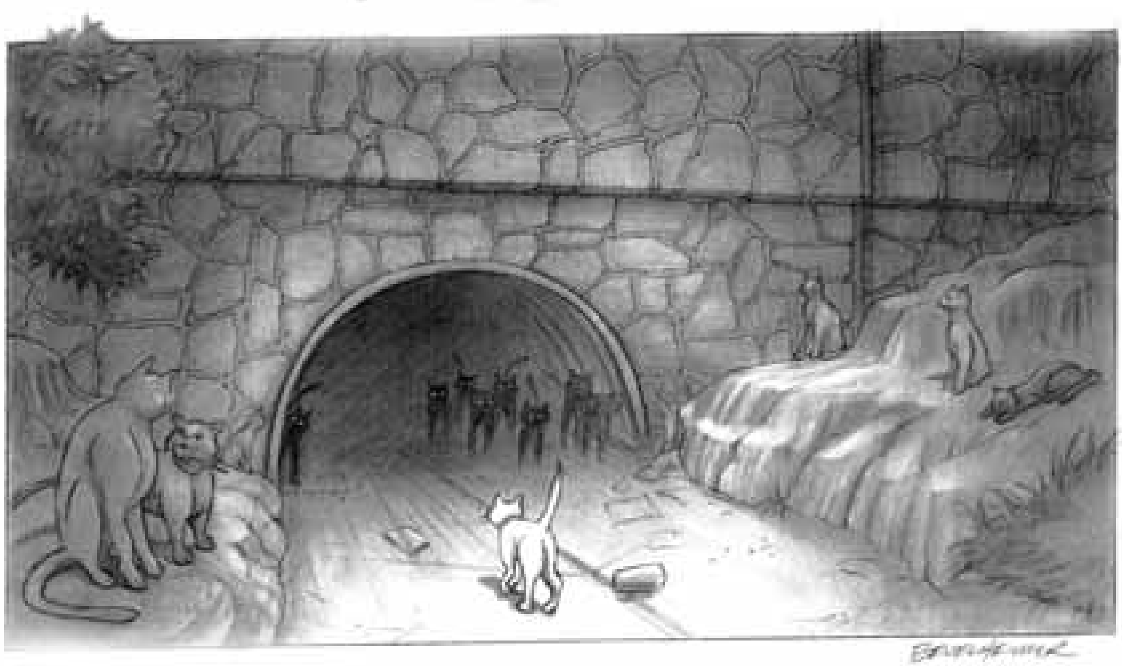
To visualize Stuart Little's character, director Rob Minkoff and other talented artists, many from Imageworks, began making illustrations, sketches, paintings, and sculptures of Stuart Little. The job was to create a look for Stuart and to determine specific parameters for the character, which would later be interpreted and translated by the computer graphics artists at Imageworks.

Ironically, the first part of Stuart to be explored was "Who he *wasn't*". That helped narrow down and define his personality. Long discussions were held about Stuart, and often in these meetings Minkoff made rough sketches of his ideas for the mouse. "First, you look at mice and what they really look like," explains Minkoff. "and then you extract from that a kind of caricature that gives personality to the creation. We needed to find different ways of exaggerating what seems natural about a mouse without falling into the trap of being too cute. A texture and an edge had to remain." Sometimes, too much of an edge would show up in drawings. Not many people have seen *those* drawings.

From Rob's sketches, artists continued to expand on the look of Stuart and attempted to find that oh-so-fine line between Stuart as lovable but not too sweet that he edges toward a phony sentimentality. "In the film adaptation, Stuart is a very pure character," says Minkoff, "so it was hard to find a handle to make him interesting and not totally vanilla."

An early idea was to have other animals in the movie that would interact with Stuart. Many animals were eliminated because they seemed to distract from Stuart's *specialness*. The only animals that survived the cut were the cats. A decision was made that the only other animal would be a cat, and that not only would they talk, but also they would talk to each other, and to Stuart. In the end though, the mice are the only animals in the movie that would talk with humans. However, the cats are an integral part of the film, and they, like every other character, human and non-human alike, went through a design phase. To the side and below are some of the explorations of the cats and their environments.





More than 300 concept drawings and sketches were made just for Stuart alone. Additionally, Stuart was sculpted in clay and plaster by artists Robin Linn, Brian Wade, Henry Darnell, and Jimmy McPherson, to give him dimension and to give everyone the ability to visualize his look more closely. Almost 40 different sculptures were created in Stuart's exploration, and ironically, none of them really look exactly like the final Stuart.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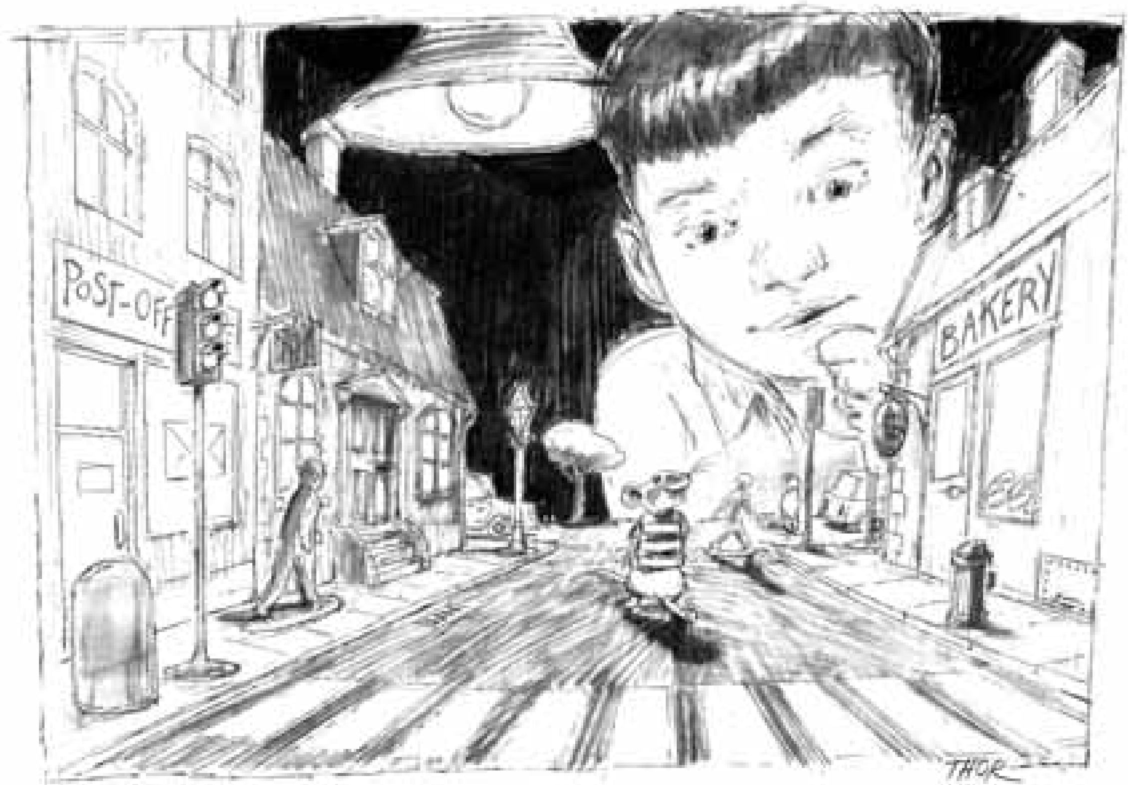
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Pre-production: Storyboards

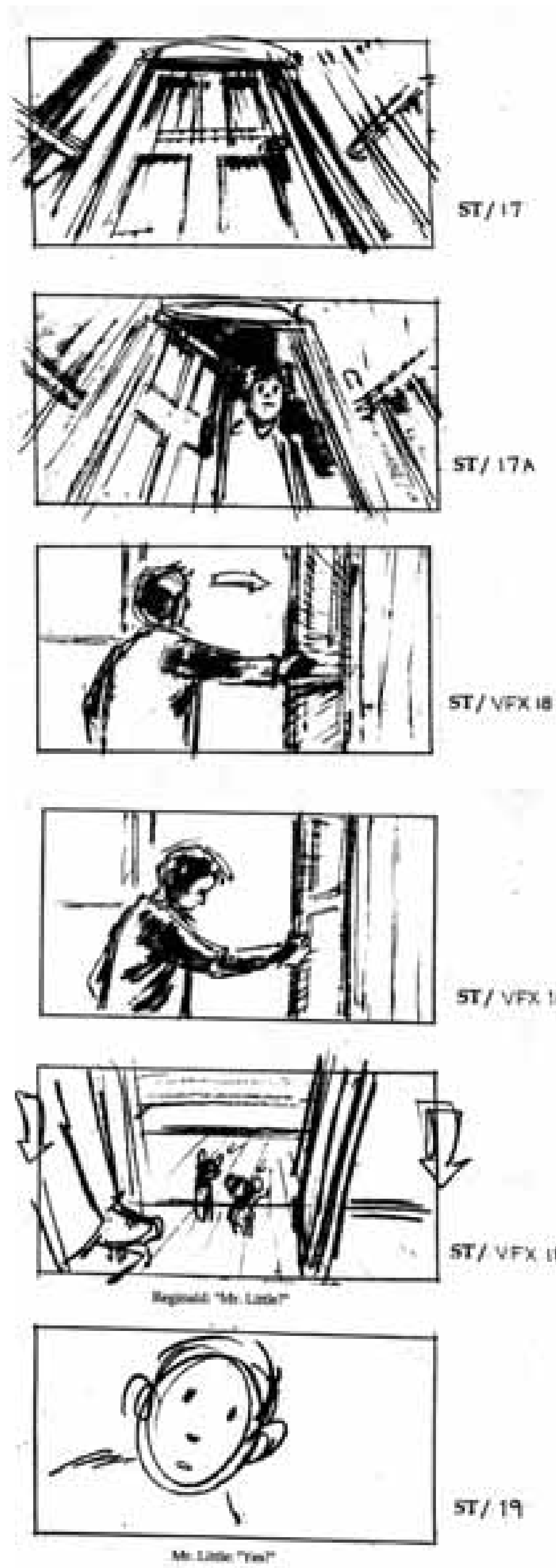
The next step for a film after characters and settings have been designed, is to produce storyboards, or beat-boards of Stuart in situations that either *were* part of the story or that *might become* part of the story. Traditional animation often uses this technique of free-form exploration to develop yet more ideas.

Artists worked on drawing of scenes from the initial script, such as Stuart in the orphanage, sailing a boat, talking with his brother, and flying an airplane. Even though some of these scenes were never filmed, these beat-boards really showed what the character would be like once he was placed in the framework and context of the film.

It became very clear right away that the studio and the director loved what they saw from the boards and the concept sketches. They also wanted more and more. It became very clear very fast, that there would be *no limits* on what situations Stuart would find himself in. The job of creating a digital Stuart was getting harder and more difficult with every drawing and with every meeting that took place.

Once the story was finalized, every scene in the script was hand drawn in storyboard or beat-board format. The boards showed camera angles, look, set-up, setting, and very importantly, scale. Since Stuart is between three and five inches tall (no one knows for sure), scale was very important to determine early on.

For a movie as complex as Stuart Little, storyboards and beat-boards are like a bible. Every change that would be made to the story or Stuart's character demanded a detailed storyboard that would then be distributed to all the departments involved. The boards were also used by the CG team and producing teams to budget the complexities and difficulties of integrating CG characters in the live-action world.



Literally thousands of storyboard drawings were made for this film, even right up until the final days of production. From a computer graphics standpoint, these boards were very important in the bidding and crewing stage. A board might show Stuart getting stuck in a piece of gum. Our team had never done digital gum before, so that would yield needing research and development time. As luck would have it, this board never showed up again as soon as everyone saw how much time and money it would take to realize.

Pre-production and Beyond

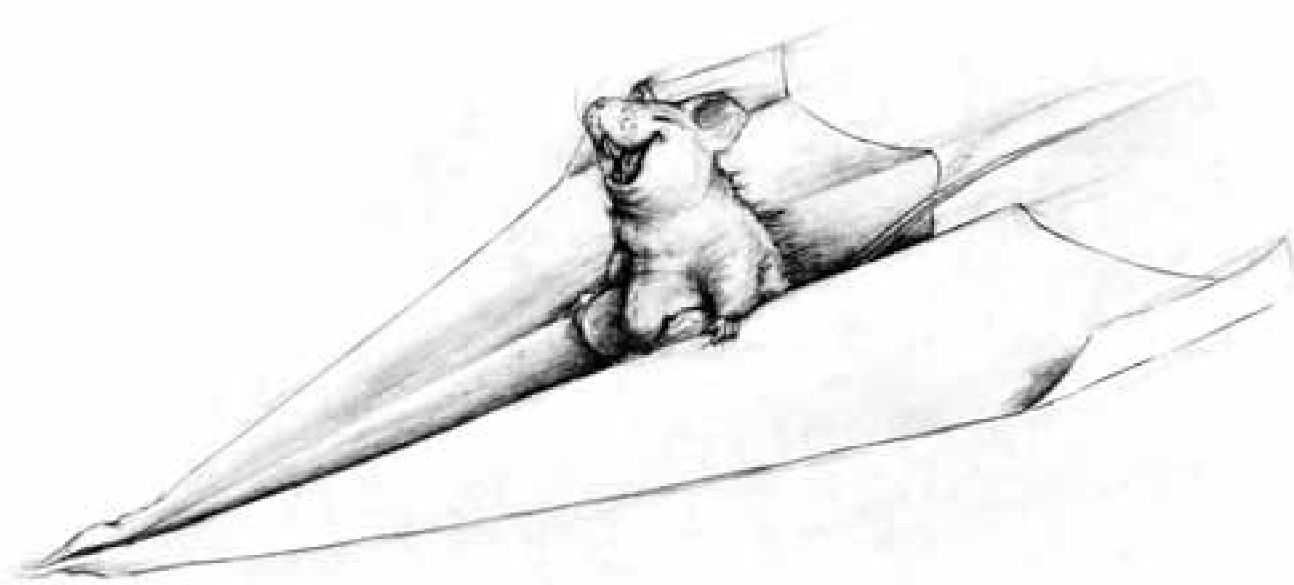
The development, creation, and realization of the character *and* the actor, Stuart Little involved four hundred days of labor on the part of 150 artists, animators, programmers, and technicians and Sony Pictures Imageworks studios in Culver City, California.

Sometimes in business and in life, one often has to take a chance, be ambitious, and start something one does not know how to do. So is the case with Stuart Little.

Yes, Imageworks had done CG for years, but no one had attempted to create a digital lead actor of this caliber, to date. The goal was clear — design and produce the most lovable, endearing, lifelike, and cute character ever created. And oh, by the way, just don't make him obvious.

This approach was quite the opposite of what most CG artists were used to, since they are used to hearing and seeing "more, more, more" fire, stars, or blood. Tending to Stuart was going to be a real challenge, both in development and realism. Words like subtle, details, tertiary, starlike, feelings, and emotion were part of the everyday vocabulary throughout this show. There was nothing to blow up, no pyrotechnics, no space scenes, no snakes, and no giant lizards. The familiarity of fantasy was disappearing.

Reality was now the reality.



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Stuart Little: A Tale of Fur, Costumes, Performance, and Integration: *Breathing Real Life Into a Digital Character*

Early Ideas, Requirements, Scope of Production

John Dykstra
Sony Pictures Imageworks, Culver City, CA

Early Ideas, Requirements, Scope of Production

If you are familiar with E. B. White's book Stuart Little then you know that the story revolves around the Little family. The Littles live in New York. The charm of the story is that everything about the family and the city in which they live is slightly eccentric. The film adaptation of the book could have easily been an animated film. However it was decided that the story would be much more engaging as a reality based piece. This meant that we would photograph live actors in real sets and locations. Production design, costuming, and cinematography went as far as they could, in creating this unique world. Visual effects were then used to add the eccentricities that couldn't be captured in original photography. Matte paintings and bluescreen photography were used to create our unique version of New York City. Miniatures were used to create scale for the boat race sequence and "Funland", the miniature golf world. Three dimensional animation and texture mapping were used to make cats talk. The greatest challenge was in the creation of the characters.

The story centers on a mouse, Stuart, the Little family's second son. No ordinary mouse, Stuart walks erect, has a wry wit and is a very natty dresser. He is definitely not your ordinary mouse. As engaging as Stuart is, a very important part of the charm of the book is that the human characters pay no attention to the fact that he is a mouse. That works well when you are reading a book, the visuals are left to the imagination. But we were now going to interpret the written word into a photo-real image. Perhaps our most important task was to make the mouse character so real that you just might believe it was a live mouse in costume. A live mouse that's acting performance was so engaging that the theater audience would never question the sanity of carrying on a conversation with a mouse.

Character Development

Most aspects of the character development were inter-related. The design of the visual and performance personality of the mouse, the animation technique, details of fur and clothing and the visual integration of our character into the live action plate. All of these pieces had to be developed in parallel. The personality of the character had first priority. We did extensive storyboards of script sequences to get a sense of what Stuart might do. Rob suggested Charlie Chaplin as an early performance reference. Our storyboards also explored camera position and composition. When your lead is 31/2" tall, playing against 6' tall human characters you have to think about depth of focus and camera angles in detail. At the same time the storyboards were being drawn, we continued the exploration of Stuart's visage. We began with sketches and then moved onto maquettes, each new version refining the character. The final character design was done in the computer using early versions of the fur and clothing software. Everyone was reviewing and approving the character in the medium that would be used to produce the final product.

As for the design of Stuart's face and body, his face had to be animal enough to feel like a real mouse and at the same time had to have enough human characteristics for the human expressions to read.We wanted a very expressive *real* mouse as opposed to a cartoon character. His body also had to have animal sensibility, while being human enough to comfortably walk erect and express body language.

An important part of Stuart's expressiveness is his hands. His hands are featured when he holds things or gestures with them. When real mouse paws were used, and looked claw like and scary, we gave him human hands and they looked grafted on. The compromise hand was longer and thinner than a human hand but had an opposable thumb. As with all Stuart's best attributes, it didn't draw attention to itself.

Fur

The texture and color of Stuart's fur were critical to the character's reality. Stuart's fur and the flesh beneath it had to exhibit all the attributes of a living animal — the scale and quantity of the individual hairs, how they moved and interacted with the skin, and that they were attached. The fur had to have specular surface that would reflect environmental lighting and give Stuart's fur sheen. At the same time the fur needed to transmit light, almost becoming a light source itself when backlit. The transmission factor was also critical to making Stuart's flesh have the "glow" of living tissue. The mouse fur also had to be effected by the environment, objects and clothing had to displace the fur, wind had to ruffle the fur and Stuart had to weather various amounts of water, from damp to completely submerged.

Cloth

Stuart's wardrobe was designed like any other actor's wardrobe. Sketches were used to make initial choices as to style and color. But in Stuart's case the fittings took place in the computer. Because the mouse wears doll-sized costumes, special care was given to the scale of the weave and the seams — just like the character's fur, the clothing had to react to the environment, windy, wet, or dry.

CG in a Live-action World

As the static design of the character was being refined the Imageworks team was building the pipeline through which each shot in the film would travel. One of the requirements we set for ourselves on this project was to keep the visual effects process as low profile as possible to the live action photography. The more constraints placed on the live action, the less intuitive the performance. We abandoned the use of motion control as a source for match-move data. As a result the first step, after scanning, in the processing of a shot was creating a match-move from the original photography. Because of the size of the mouse we were very close to objects during the plate photography. This proximity amplified all the linear camera moves and made the match-move work very difficult. The accuracy of the match-move was critical to the believability of our CGI characters. After match-move came the Animation step.

Software

Custom plug-ins were developed for the Maya software that would streamline the animation process and ease the transition of traditional animators into the realm of 3D-computer animation. In the early days we explored the possibilities of motion capture for all or part of the characters performance.

The Whole Process

At the same time, we were developing the key frame system. The key frame package showed much promise in its early versions and the motion capture seemed overly complex because of the non-human proportions of the characters. So we abandoned motion capture. We also began the construction of an anamatronic version of the mouse, assuming that we could use him for very wide shots where the mouse was literally a "dot on screen".

Once we had approved the performance animation, the character was costumed. The furless mouse was "dressed" and the animation run again. The doll costume scale was important to the look of the motion. The cloth needed to move easily enough to show wind and gravity. But it also had to exhibit the "stiffness" that dolls clothing has in Stuart's size. As we had expected as we added Stuart's movement, we had to go back and adjust the tailoring of the costume to accommodate his range of motion.

When the clothing was satisfactory we then began the final combination. The base line for the composite step was to get the lighting to match the original photography. Just like the match-move, if the lights for the CGI characters have the wrong color, quality, brightness or position, it will give the gag away. When we got a general lighting match, character to plate, we then added the accent lights that are used in live actors to make the "Star" look good.

As an example of accent lighting, we always gave our mice a rim light to separate them from the background and to give their fur highlights. If you light a white mouse so that there are no highlights, any areas of the fur that *are* white, read as a *gray* colored. So special care was paid to contrast at all times. Once lit, the CGI components must be integrated in a composite image.

The composite step is by definition where two or more images are blended. With Stuart, our goal was to make the visual cues so complete that the audience would believe they were viewing original photography. The visual cues go well beyond a good matte blend. Shadows both cast and contact, and reflections help "land the character" on surfaces that he comes into contact with.

Other visual cues, such as blushes of color in the white of the fur cast by objects close to the character, and reflections in the black sphere of Stuart's eyes, appropriate to his environment, helped to bring Stuart to life and give direction to his gaze. Those *details* tell the audience that these images are not separate pieces but are all part of a real scene.

The "Screen Test"

We knew that the CGI characters were going to evolve over the entire length of the production and that changes made to any one component of the character 's make-up would effect all the other components. Once the pipeline was roughed in, it was time to use all the elements to complete a shot. Production hadn't begun yet so we decided to do "a screen test". The screen test served to give the effects crew a date by which the match move, animation, fur, cloth, lighting and composite pieces had to be used in a shot. Where there were alternate techniques in consideration, one had to be chosen. The test also served to give the studio notice that we were finalizing the character. The time for changes was coming to an end.

Although the test was never completed, it gave us valuable information about how all the puzzle pieces actually had to fit together and how long it would take to assemble and polish them into a seamless illusion. If our team has been successful, three minutes into the film, people will forget that they are watching an "effects movie".

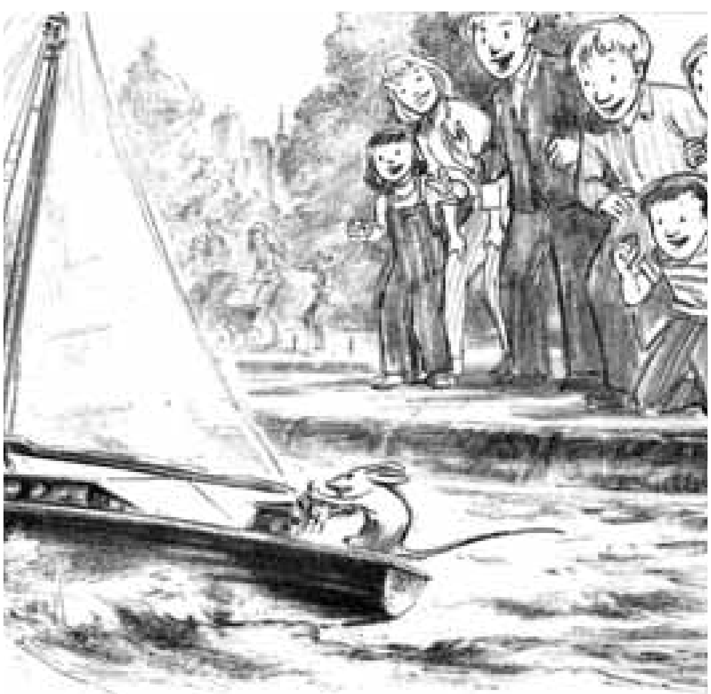
As with most projects of this scope, the initial requirement was to get a broad sense of the quantity and cost of the work needed to tell the story. We had a schedule and a target budget, but we made our first pass at the script including everything that we could possibly want: the number of shots, the complexity of those shots and the technique, practical or CGI. We included the miniatures, hardware, and software needed, to have as much flexibility as we could possibly want. Obviously the schedule and cost for this version of the work was too long and too expensive. What this did, was give us a shopping list of techniques. In order to reduce the time and cost, we had to reduce the quality of the final product, or figure

out a way to increase the efficiency of the process. We had no intention of lowering our quality standards, so we had to find efficiencies. The flexibility that we built in to our first pass was very costly. We had to narrow the range of possibilities. Often this meant choosing between traditional effect techniques and CGI. They both have their advantages and limitations. All the compositing was to be done digitally so what we were comparing were the methods of generating the original images.

Sequences – The Boat Race

The easiest way to show this process is to use a sequence as an example. The Boat Race was a sequence that was definitely going to be in the movie. There were a huge number of versions of the race. We had our mouse in a very physical boat race in the Central Park Lake on a very windy day. The sails had to flap the mouse fur and clothing had to blow. Amidst the spray, some boats had to collide and sink.

We wanted to heighten the jeopardy of this scene so we decided to shift to a decidedly “mouse” perspective. The humans were experiencing a brisk breeze. The mouse was in a force six gale. To the humans the little boats bumped against one another. For Stuart the “bumps” were of Titanic proportions. To create this perception shift we wanted to “scale” all aspects of the experience. Slow motion would give the water and the boats more weight. Mouse eye height camera positions would put the viewer on the boat with Stuart during the experience.



Obviously, creating this world in CGI would give us complete flexibility. We could position the camera anywhere, and control the apparent speed of the action to fractions of a frame per second. By doing this scene all in CGI, we would have used the films whole visual effects budget for this *single* sequence. So we took the sequence apart to find efficiencies.

We know that the live action portion of the scene will be shot on stage using model boats on real water. The stage would have to have a somewhat defuse sun source and use backings for the surrounding city. Because the boat race inter-cuts with the live action from stage, we would have to match it.

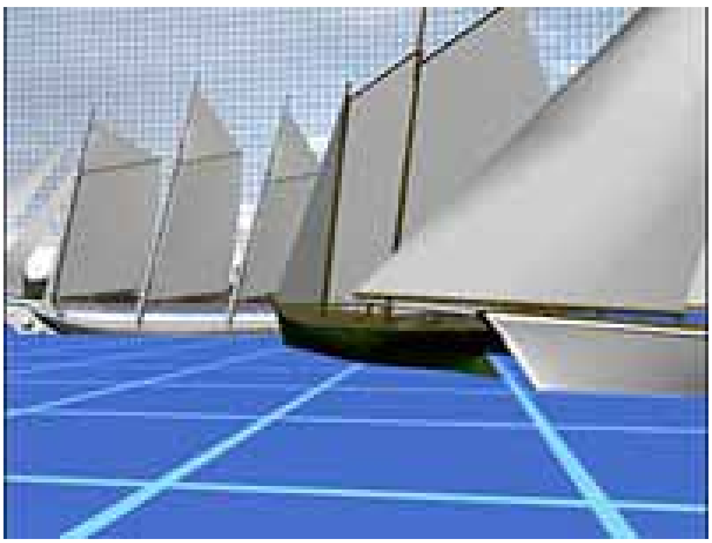
Modeling the water and the boats in CGI and getting them to match the real water and boats from the live action would be very expensive. A tank and miniatures seemed to be the best alternate. The advantages were that we already had some of the miniature boats completed, and by shooting in real water we would have no water quality matching problems.

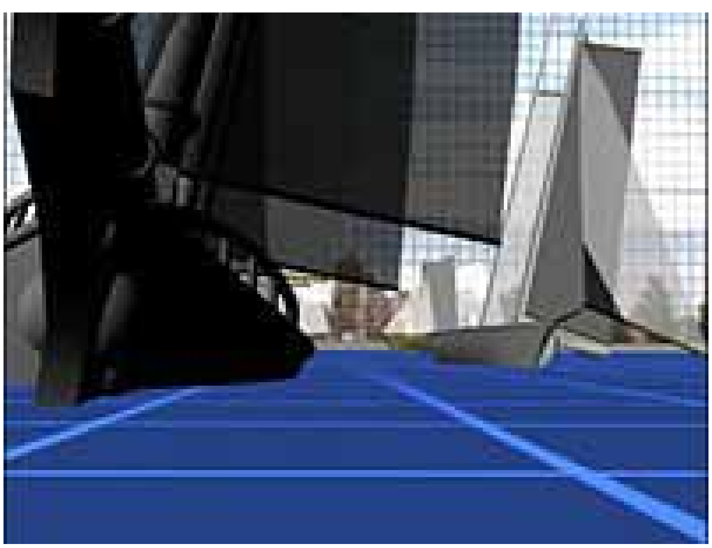
The distant city in this part of the sequence could be done as a backing and would also match. We would even be able to use an animatronic mouse for some of the wide shots and save some budget. But ... Could we get close enough to the deck of the boat in amongst the rigging or the surface of the water using the miniatures? At the scale of the miniatures we had, the lens and camera would be a very tight fit. Could we slow the action down? Of course, we could shoot high speed but that means more light. We would also need extra depth of field to keep the mouse's world from being all fuzzy foregrounds and backgrounds, and that means even more light. Wide lenses can help with the depth of field problem, but they will show more of the background, and require a larger tank and backing. The lighting match to the live action would require a diffuse source. The mechanics to position and move the miniatures in the tank are complex. We would need to be specific about the paths of each of the boats for each shot. Therefore, this leaves *a lot* of questions to be answered.

Pre-visualization

Time for one of the most powerful tools in the computer arsenal, *pre-visualization*. We modeled simple versions of Stuart, the boats and the lake environment in the computer, and then defined the shots completely, down to the speed of the boat and the focal length of the lens. By editing these pre-vis shots together, we had a complete definition of the physical and emotional needs of the sequence. Once the sequence was roughly edited, we knew what angles and how many shots were needed. Now we had to see what money, if any, could be saved by using practical elements in place of CGI.

Based on the pre-vis we discovered that the standard size model boats were ok when photographed in the background, but we couldn't get the camera close enough to the water to photograph them close in. Also, there wasn't enough room in the rigging to insert even a probe lens for the mouse POV across the deck. We discovered in using the pre-vis, that by doubling the scale of the boats, we could get the camera positions that we wanted. What if we only double scaled the boats that we would get close to — Stuart's boat the WASP, and his competition, the Womrath? By adjusting the scale of these boats in the pre-vis, we found that we could mix scales. Put the larger boats in the foreground and the smaller boats in the background. In fact, the scale difference worked in our favor by forcing the perspective of the lake. As it turns out, the larger scale boats also helped us with depth of field, and we didn't have to shoot at an extremely high speed to get the proper scale for the collisions and the water effects.





The miniature solution would in fact work and save substantial money without limiting our quality.

The tank shoot would be expensive, and we needed to be certain that we could get what we wanted before we began photography. In order to get the amount of light we needed to carry depth of field and shoot high speed, we decided to shoot in an exterior tank. Would we have to build one? Or would an existing tank do the job?

By adding more details to our pre-vis model we could be very specific about what we would see. We had our mix of single and double scale boats and camera composition. We modeled an existing tank and backing into the pre-vis. A model of a telescoping crane and remote head were attached to our chosen lens positions. Now we could see what limitations we were facing in this practical environment.

By modifying a couple of shots we were able to fit the sequence into the tank without any real sacrifice. The pre-vis model then became a blueprint for the shoot. We knew where the cameras would be positioned for each shot, how far they had to move, and when they would see each other, lights or off the backing. We knew how big the silk overhead would have to be. We knew the scale and position of the ground row that separated the edge of the water from the painted backing of the city. We knew where the boats had to start how fast they had to go and where they had to stop. These details allowed us to schedule the work in a progressive fashion. The shots with the most common setups were shot together, optimizing the time.

Without pre-vis, we would have shown up with storyboards and a rough idea of what the composition should be. We then would have spent the better part of the day blocking the action. Remember, moving the track for one boat could take the better part of an hour, and there were twelve boats in some of the shots. At the end of the day we would have to shoot whatever we had, good, bad, or indifferent. In most cases we would only get to try out one blocking for each shot.

With the pre-vis and the model of the shooting environment, we could try two or three completely different blockings in the time it would take to move only one boat on the practical set. Because the crew had orthographic scaled drawings for the boat tracks and speeds they could rough the setup in over night. When we showed up in the morning we could spend the day putting finesse into the shots. Because we knew accurately what the camera would see, we could schedule shooting in one part of the tank, while tracks were being rigged in the part of the tank outside the field of view.

Having worked without the accuracy of pre-vis in the past, I can say without reservation, that we would have spent twice as much time to get half of the usable material. The pre-vis allowed us to edit the sequence prior to shooting. We could define the character performance, story telling and pacing. The shots began and ended in a way that makes the editing much smoother and we spent time on finesse of lighting and action instead of just trying to block the action. The pre-vis technique was used throughout the production to focus our energies on the *finish* and not on the *process*.

Course #14, SIGGRAPH 2000
New Orleans, LA, USA

Stuart Little: A Tale of Fur, Costumes, Performance, and Integration: *Breathing Real Life Into a Digital Character*

Research & Development: The How's and Why's

Jay K. Redd, Jim Berney, Scott Stokdyk
Sony Pictures Imageworks, Culver City, CA

Research & Development: The How's and Why's

The R&D (research and development) period happened simultaneously in multiple departments. Though the character model was the clear first step, as soon as it was 'released' to the other teams, the rest of the show began it's exploration. Think of the model release as a 'bone thrown to a starving dog'. The fur, cloth, effects, lighting, and animation teams virtually went berserk over the opportunity to be able put something on the mouse. Stuart the character was begging to be clothed, furred, lit, and animated. Plus, the studio really knew what Imageworks was up to, causing them to want to see even *more*.

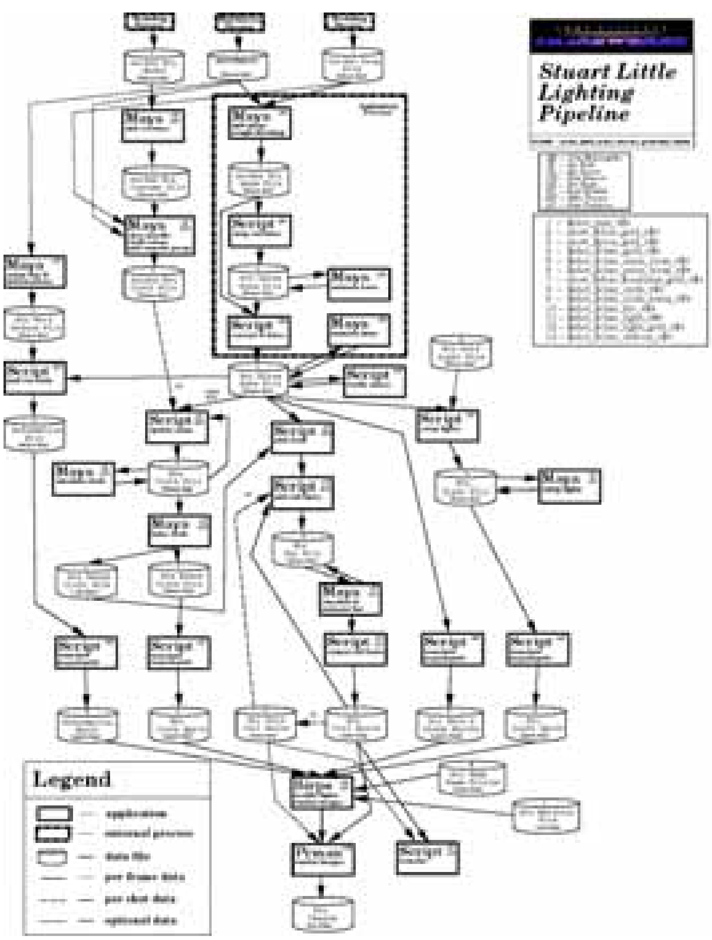
It would be impossible to determine how many meetings and discussions took place during the making of this film, but they are a necessary evil of a production of this size and detail.

One of the early meetings was to determine the digital 'pipeline', or the way things would be done, where they would come from, who would hand-off what, who did what, and how long each step would take. A result of what the digital team would come up with during a few of these meetings, is on the left.

The show was divided up into 3 separate but integrated parts, to 3 different CG Supervisors. One for fur, one for cloth, and one for compositing/effects/ animation. Each area had it's own distinct requirements and attentions, but would ultimately need to 'speak' with the other parts of the pipeline. There was a lot of cross-over and cross-talk. The 'pipeline' as everyone calls it now, was yet another bible to guide the show by. By the end of the show, all of the CG supervisors spent time in each others 'areas' of responsibility, as each sequence required mostly the same things.

The example on the left is a very broad overview. Each portion of the pipeline actually has yet another *sub-pipe* underneath it. It sometimes takes on a 'fractal' life of it's own, getting more complex, the deeper the view.

The Stuart Little production pipeline as of 9/98 is on the left.



Character Design

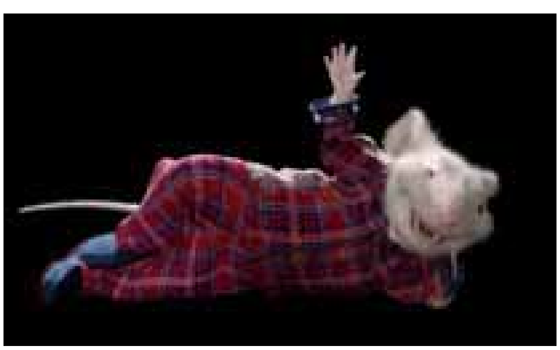
After dozens of rough sketches were drawn by Rob Minkoff himself, Imageworks animator Todd Wilderman, storyboard artist Thor Freudenthal, and the many clay and plaster sculptures of Stuart were made, the visual effects team began the digital, 3D, and pipeline development of what would become the digital character and actor named Stuart Little.

Pretty much everyone agrees that as the leading man and the protagonist of the film, Stuart needed to be both cute and lovable, though his "cuteness" was a much discussed, debated, and subjective topic.

Again, the dictionary states "cute" as thus:

cute adj. –
1. Delightfully pretty or dainty.
2. Obviously contrived to charm; precious.
3. Shrewd, clever.

Care was taken to stay away from definition number 1, and the bad parts of mice that might frighten people or not be so charming. There were, of course, dozens of ideas of what really made something "cute" in a mouse. Big eyes, short snouts, big ears, large hands, and other baby-mammal characteristics were discussed. Unfortunately, there is no "cute" magic button or slider that has a "cute" parameter assigned. Charming, precious, and clever were definitely ideas that everyone wanted to see in Stuart as he was designed, though many subtle but immeasurably important aspects of 'cute' were more difficult to define.



As mentioned previously, a lot of time, talent, and energy was put into designing Stuart, especially a character that is supposed to carry an entire film. While there are many obvious things that go into designing a character such as eyes, hands, and nose, there are the subtleties of each of these items that requires addressing.

Since Stuart was completely digital, every facet of his being had to be looked at and designed. This means that there was a meeting or discussion or drawing for virtually every part of his body.

Of particular note, and a question that gets asked frequently is "Why does Stuart have five fingers?", or "What made you decide to give Stuart, little-boy hands?"

Those questions bring up a long winded history into the design process of Stuart's character as a whole. Like the rest of his body, his hands went through test after test after test. The first tests showed a few drawings of Stuart with 3 fingers, a la Mickey Mouse. Other artists drew Stuart with 4 fingers.

What was quickly apparent was that there was 'something wrong' with the way Stuart's hands looked with less than five fingers. His non-five-fingered hands were too obvious and almost too grotesque. People, including the visual effects team, tended to focus on the hands instead of the character as a whole.

Human beings have an incredible ability to detect when something 'is wrong' or 'isn't quite right'.

It was the Stuart Little crews' job to determine not just *what*, but *why* something wasn't quite right.

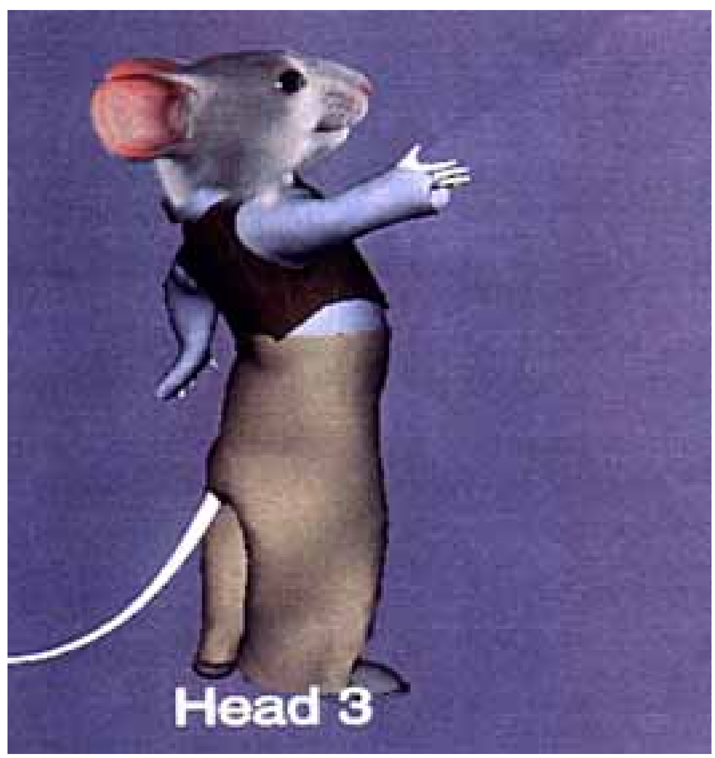
Since Stuart Little's movie persona was more that of a little boy than a mouse, that approach was taken, with the introduction of five-fingered hands. Bingo. No longer did people spend time focusing on just one aspect of Stuart, but instead fell in love with the entire character. His head, whiskers, eyes, tail, ears, mouth, feet, and every other part of Stuart's being went through this painstaking, and sometime patience-testing design process. As an example, Stuart's teeth are based on the dental scan of Imageworks Senior VP of Animation, Barry Weiss. Kevin Hudson's modelling team spent quite a bit of time getting them 'just right'. Barry's front two teeth weren't as long and mouse-like as Stuart's, thank goodness.

Many, many variations on the look of Stuart were explored. However, when the team finally came up with the final image, everyone agree on it. There was no doubt in anyone's mind that it could be presented to the studio.

It's amusing now (if not painful) to look back on the earlier versions that were explored, and to think that he even approached "cute" back then. It was a good epiphany — that moment when the mark was hit.

The epiphany occurred when the image of Stuart, lovingly known as "*Head 3*" — was signed off by the director.

Still, there was *much* to be done.

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Course #14, SIGGRAPH 2000
New Orleans, LA, USA

Stuart Little: A Tale of Fur, Costumes, Performance, and Integration: *Breathing Real Life Into a Digital Character*

Modeling and Facial Animation

Jay K. Redd
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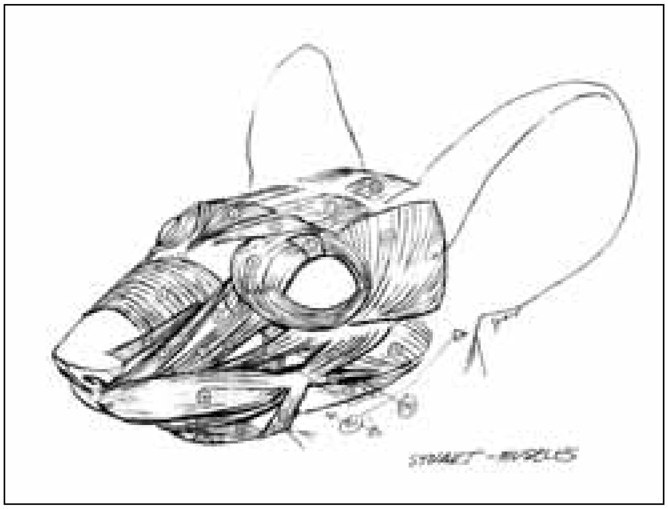
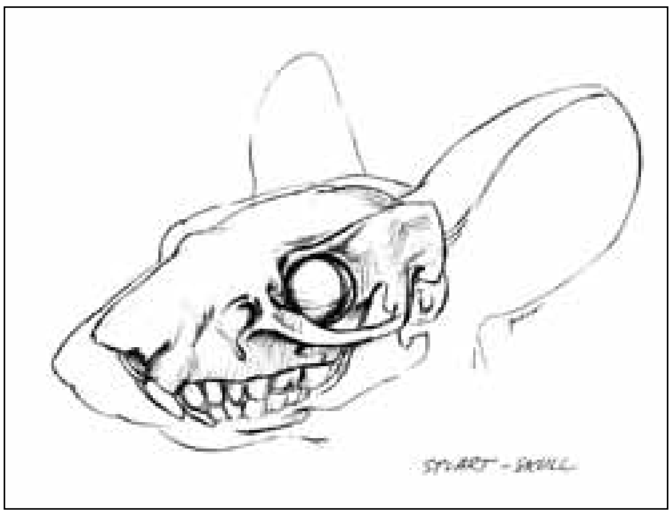




Modeling and Facial Animation

Since Stuart started off as a series of artist concepts, sculptures and sketches from the director himself, the 'final' sculpted version of Stuart that everyone agreed on would serve as the jumping-off point for the digital version of the character.

In early 1998, the final sculpture was scanned and the data taken in to the Imageworks modelling department, headed by Kevin Hudson. The point-cloud data was huge and imperfect, so Imageware's Surfacer software was used to create the basic NURBS patches that were then loaded into Alias PowerAnimator for final digital sculpting, cleanup, and revisions took place.

Seeing the new digital still-posed version of Stuart was extremely important in determining his persona. He would have to come from the same media that he would be in the film. Interestingly, Stuart could rapidly lose his "cuteness" everyone had worked so hard to achieve, simply by a change of lens. Use a wide-angle or short lens, and his snout would change, use a long lens, and his face and ears would lose their "cuteness". A lot of care was taken on making Stuart hold up and retain his "cute" qualities, even if in the film, he was in dire straits.

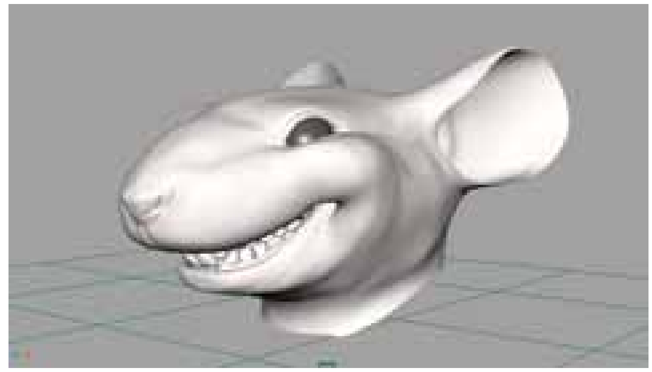
All of his "cuteness" was fine and good as a still pose, but could he act? Does he have interesting and convincing facial expressions? It was determined that Stuart walked on his hind legs. This created many questions for the artists and animators. "How does he move his legs?" Now that it was decided he had five-fingered hands, the question arose, "How does he hold them?" Sometimes the answers actually created more questions.

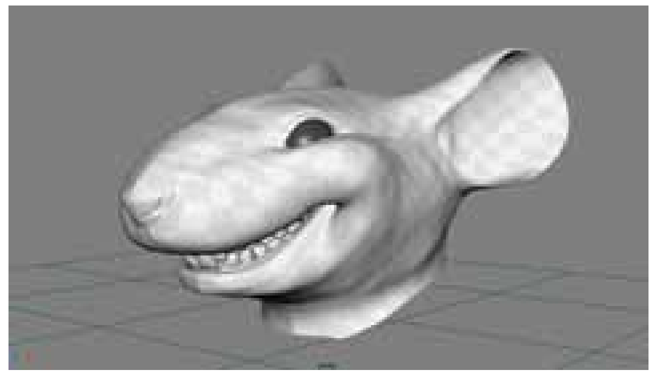
Imageworks training department, headed by Sande Scoredos, brought in Dr. Stuart Sumida (no relation to Stuart Little), a professor of anatomy at Loma Linda University. After Dr. Sumida provided consultation, the team was advised that a mouse would keep his hands up and keep them tightly clasped. Why?

"Because this is what mice do." Sumida said.

While Stuart's hands were being figured out, his face became the next target. Since the pipeline was nowhere near ready for shots, animation tools were being researched and developed. Crucial to Stuart's need of convincing the audience and connecting with them, his face had to move in such a way he wouldn't ever look *computery*.

Constant attention and daily review took place in order to make sure that Stuart's face didn't look rubbery or stretchy. Phonemes, sounds, and voice patterns were studied. Since the fur was not completely ready while final face and blend shapes were being made, the animators spent a lot of time avoiding assigning too many or too few points to each face shape, giving it an unnatural or stretchy look. A simple checker board pattern was applied to each head to check where areas looked to be stretching.





Karl Gnass assisted with life-drawing classes that taught the facial modellers how muscles would flow, were they mapped onto a mouses skull. Karl and the modellers also explored different theories on the evolution of feeling and expressivity. Emotions are very fast and fleeting things. They happen in a micro-second. The digital sculptors needed to be actors to regenerate those fleeting split-seconds over and over again as they created the multiple blends and face shapes.

Stuart was up on screen with other big stars Geena Davis, Hugh Laurie, and Jonathan Lipnicky. He had to carry the picture, and people had to believe his expressions were real. Since the root of facial expression is expression and emotion, Stuart and the other digital characters would have to perform every bit as good with their faces as the other stars. This aspect was kept in mind during every aspect of the modelling process, and indeed during the entire show.

After all, another digital character was not being created — a digital *star* was!

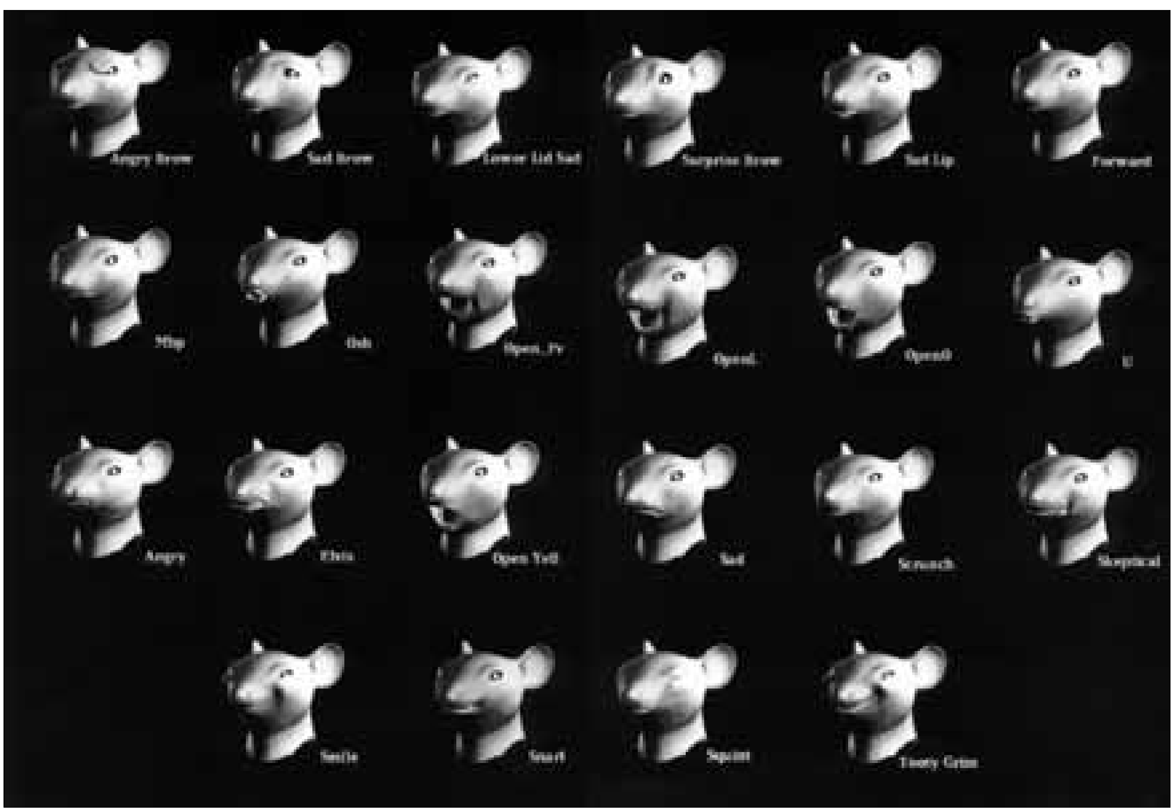
There were three main artistic requirements for the face shapes:

1. They needed to be *authentic*.
There had to be an underlying believability to the face shape, both biologically and artistically.

2. They needed to be *charismatic*.
Stuart and the other characters needed to clearly express the intent of phoneme or expression.

3. They needed to look *cute*.
The characters, particularly Stuart, needed to always be cute and appealing, regardless of what they were doing.

All in all, Stuart had over 124 different animatable channels in his face. Many of the face shapes were built asymmetrically, to gain yet more control over the morph or blend objects. Periodically, one face shape would be built for one word that appeared in the script that required a particular face. All of the blends in Maya were not limited to 100%, but rather 150%. This gave the animators more control in anticipations and extreme emotional situations.



Fur wet/dry, skin, texturing

While other design issues and character appearance issues were being worked out, the fur team set out to create photo-real hair and fur that would have to stand up to the most demanding of scrutinies – that of a digital star that would be on screen, all the time, in all manners of close-ups and angles. The team, led by CG Supervisor Jay Redd, consisted of a core group of three programming TD's, two software engineers, and a new TA, turned digital hair styslist and lighting TD.

Before any lines of code were written or any pictures were taken, yet another meeting (YAM) was called to determine what Stuart's fur required. After all, it's all in the planning. A list if simple but ambitious goals was made and used as the starting point:

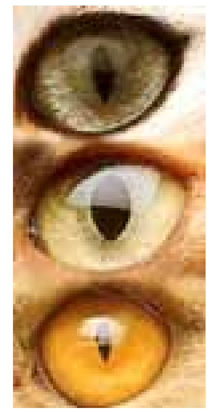
- **Must be cute, realistic, and convincing.**
- **Detailed fur regardless of size on screen**
- **Realistic lighting model, shadows, diffusion, environement, etc.**
- **Flexible controls when absolute realism is not necessary or wanted**
- **Multiple lighting environments (day, night, sourcey, diffuse)**
- **States of fur (wet, shiny, dirty, oily) and ability to transform from state-to-state**
- **Fur interaction with environment (wind, other objects, self. clothing)**
- **Multiple furry characters and costumes on screen at one time**
- **Enough efficiency for 500 potential shots**

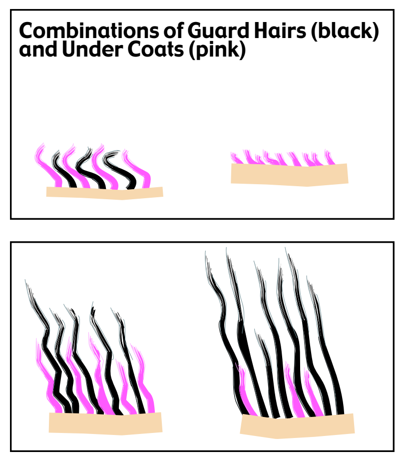
The approach to creating the 'most realistic fur ever created' started with the exploration of what had been done before, what existed as current software, and what the demands of the show were. Simply put, after reviewing the work that had been done up to early 1998, and though amazing, nothing really compared to what was required for Stuart Little.

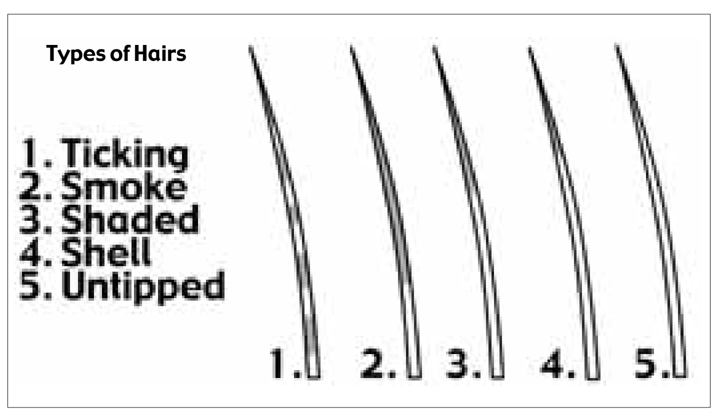
First of all, Stuart was a white mouse. This created all sorts of difficulties. He acted as a "chromatic sponge" as John Dykstra put it. Meaning, since Stuart was white, he would pick up and reflect back any hint of color that hit his fur. Lighting something that is white, for film, is very difficult. Film response is extremely sensitive in the upper registers of the curve. Too much light, and Stuart would be blown out and featureless. Too little light and he would look dingy, dirty, and heaven-forbid, *not cute*!

There were mutiple issues with fur color from the studio's standpoint. In this day of *political correctness*, everyone was very sensitive that Stuart and the Stouts not be put in a certain situations, or worse, were they to have dark fur, to do *bad things,* and in any way offend any minority communities. This was merely one impetus to create a light, translusive, refractive, and organic quality to the fur.

The team started the process by meeting first with Dr. Stuart Sumida, to determine not only the make-up and properties of the fur, but the characteristics of the skin beneath the fur. Dr. Sumida provided information as to the make-up of mammalian fur, such as "guard hairs", "undercoat", and "mid coat".







Visual Research

The process started with visual research to document all the scientific information Dr. Sumida was providing. This research was comprised of photgraphic lighting tests, texture tests, distance tests, and exposure tests. The goal was to see what would and would not show up on film, given any of the above combinations.

Since there weren't any limits in the development of what Stuart would go through, his fur had to be designed and ready to take anything that was thrown at it.

The images were shot with rolls of Kodak 5279, the same stock used for the majority of the film. It was important to stay as consistent as possible during the development period, since so many tests on so many levels were being conducted.

Interesting and difficult to recreate color, contrast, and texture aberrations began to appear when looking at various samples of fur photographs. The photographic samples began to bring up topics such as refraction, diffusion, and scatter. The effect of white fur against a *dark background* reduced the apparent detail in the fur. Conversely, certain white fur against a *bright background*, made the white fur appear dirty and overly textured. Hair and fur were certainly complex. No third-party or pre-packaged software provided anything near what was needed. It became clear that Stuart needed special care and attention. This translated into *hard work, time,* and *development.*

Hair Generation

To clear up any confusion, “hair” is simply an individual piece of keratinous, pigmented, cylindrical or ribbon-like filament growing out of the epidermis of a mammal. “Fur” is simply a thick coat of “hair”. “Hair” is individual, “fur” is a collection.

It was determined early on, Pixar’s industry standard RenderMan would be used for the bulk of the rendering on the show. At that time, the new set of RiPrimitives had just been included in the latest release. This was highly anticipated, as this release allowed the team to use the RiCurve primitve to draw an individual hair very easily. Now, all that needed to happen was to draw over 500,00 of them!

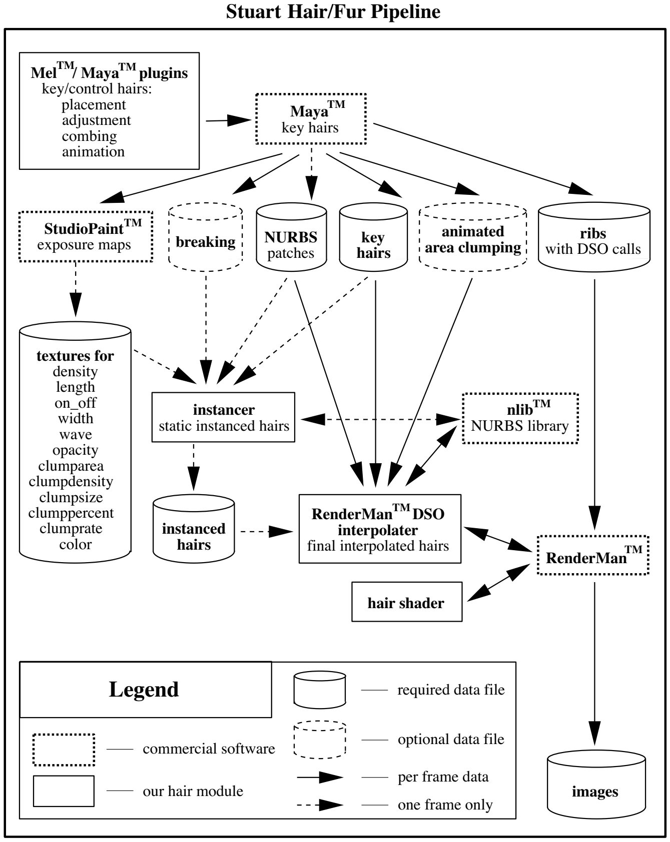
Armin Bruderlin, Clint Hanson, Alan Davidson, Bob Winter, and Hiroyuki Miyoshi were the primary individuals responsible for the implementation of all aspects of the hair pipeline. Before the road of shading and lighting was even contemplated, the question arose of how to generate a large number of hairs easily and quickly. Clint, Armin, and Alan spent long hours solving this problem.

It was very important in a show of this size and schedule in designing the fur pipeline, to leave the largest creation of data, in this case hairs, until the last possible step in the pipeline. For Stuart, this last possible step was just before or at rendering time. To the artist, the actual visual render appeared as the hair generation step. Through the use of a DSO, the RiCurve primitives are never grown onto the surfaces until the time of the render. DSO references are built into the rib file which calls yet another interpolator DSO. When put through Imagework's rendering pipeline and proprietary front-end to RenderMan, the DSO then generates RIB data which contains an RiCurve for each hair contoured and combed to the surface. This all correctly takes into account the character's animation and performance per frame. The hairs are then shaded with the Stuart Little shader and the final image is rendered.

The basic pipeline is made up of two macro processes, one that happens once for each character and one that happens once for each frame. The first process is in gathering all of the data which controls the look and contouring of the fur, then calculating as much as possible up to the last possible moment, storing it away in a series of cached data files. The second process is in the actual creation of the fur on each character from these cached data files, immediately at render time.

Most of the data for the first process (the style or combing of the hair) is dealt with via MEL scripts in Maya, Hiro Miyoshi's combing tools, and attributes controlled through creating "exposure maps" via StudioPaint 3D. Clint Hanson's instancer is then run to compile all of the proper cached data files into an "instanced hair" data file. This then specifies the location of each hair on each character. Thankfully, this step only has to be calculated and run one time at the first setup of the character, or if there is a change to the stored fur data files, such as a new combing style, generated by Bob Winter.

Stuart Hair/Fur Pipeline

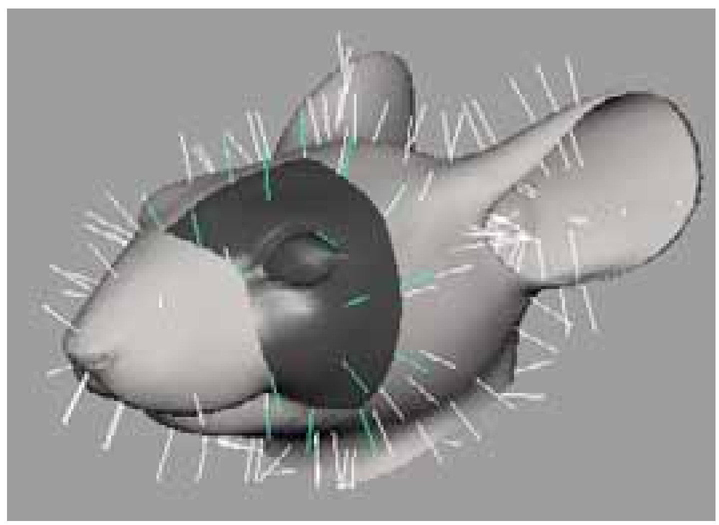


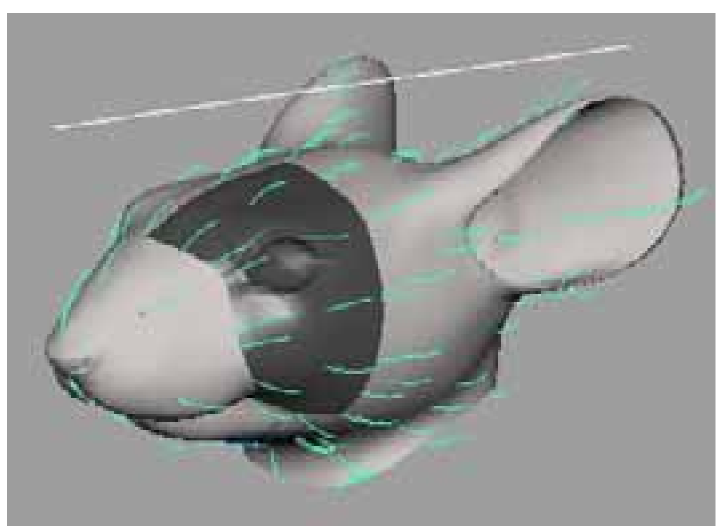
The interpolator step of the pipeline exists to "grow" the RiCurve primitives from all of the input data, which includes the following:

- **NURBS patches, static and/or animated**
  These NURBS patches make up the skin of the character. Using the surface normal and derivative of the position of interest, each hair is oriented and positioned in the correct three-dimensional space.

- **Combed and animated area clumping data from Maya**
  Taking into account the combing and styling information and other fur attributes specified in the data files, this data is used to generate the 4 point curve of each hair

- **Instanced hair data**
  For every patch in context of the UV coordinate of the surface, the instancer specifies the position of each of the individual hairs





Wet and Clumpy Fur

When R&D was started on Stuart Little back in late 1997 and early 1998, the storyboards and script of that time put Stuart in the water many times. The fur team knew from the beginning that some sort of new mechanism(s) had to be developed to handle this requirement.

Not only would Stuart get wet, he would be *in* the water, *partly in* the water, *out* of the water, and he would often be shown in the *middle* of drying himself off. Up to that point, no one had done wet fur, much less, partly wet fur, or clumpy and oily fur.

Armin Bruderlin held a special interest in this category and actually started work on research before anyone even had the chance to talk about it. His paper appeared at SIGGRAPH 99, and will consequently be covered briefly here. Because the standard hair pipeline was robust and solid, adding clumping into the mix was simpler than first imagined.

Again, research images were acquired. Real-world tests were done. People hosed down their dogs. Armin even took Stuart, the company rat, and sprinkled water on him to see what would happen.

Those tests proved useful and interesting, but since this is a movie, everything gets art directed or supervised.

"Clumping" of hair can happen when fur gets wet or coated with a liquid substance. The surface tension of the liquid causes neighboring hairs to gravitate or attract to the same point, creating a cone-shaped or tee-pee like "super-hair", or in this case, a circular clump.

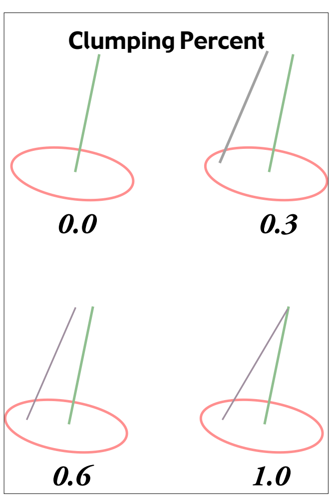
Two types of clumping techniques were implemented for Stuart Little, static area clumping and animated area clumping. Static area clumping produces hair clumps in fixed, predefined areas of a given model, and animated area clumping allows the clumping areas to move about the surface of the model. In both clumping cases, controls and parameters can be animated over time to accomplish the wet-to-dry scenes.

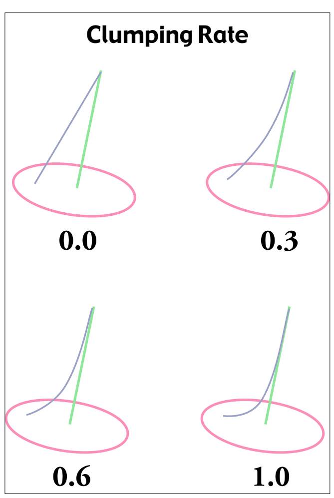
For clumping there are four parameters required as input:

- clump-density =
  number of clumps per square area
- clump-size =
  area of a clump in world space
- clump-percent =
  degree of clumping for a clump hair
- clump-rate =
  how tightly a clump hair clumps

These four parameters can be controlled via user-defined numbers or with "exposure maps" or texture maps. These maps can be used to *expose* where on the model the clump should take place, instead of across the entire model.

The four images on the right show an animated clump-percent and clump-rate sequence. In the first image, clump-percent and clump-rate are zero. In the last image, both values are set to one, producing a very wet, almost vaseline-like effect. This clumping, combined with one of Bob Winter's digital hair styles, could produce very dramatic, convincing, and sometimes scary results. Again, ease and care was taken to not go overboard with clumping, scaring off people.





Shading and Lighting: Fur and Skin

To be able to render large amounts of hair rapidly and efficiently, the geometric model of each hair is kept simple. Instead of using tubes or cones, RenderMan's RiCurve primitive was chosen. This primitive is made up of small micro-polygons following along a specified curve (hair), with their normals pointing directly towards the camera at all times (think of a two-dimensional ribbon always facing you).

The RiCurves render very efficiently compared to other types of geometry, but what it leaves is the problem of how to shade and light a two-dimensional flat ribbon, so that it looks like a thin, round, and cylindrical strand of hair. Of course, efficiency had to be kept in mind every step of the way.

As Stuart was the leading man in the film, he would be seen everywhere, with everyone, including Geena Davis, Hugh Laurie and Snowbell the cat. These actors would be lit and treated like movie stars. There would be no less treatment of Stuart, even though he wasn't even on set.

Because Stuart had to exist in the *real* world as a movie star, special lighting tools had to be developed to deal with such a special character in the CG world.

The term "magic lighting" was coined to describe how Stuart would be lit in every scene. He would be treated like the stars of yesteryear – with style, grace, and magic. A typical two-to-one lighting ratio would simply not suffice in this fairy tale.

Starting again with reference as the guideline, effects of different types of light on different types of hair were explored. Backlighting was tested, as was day and night light.

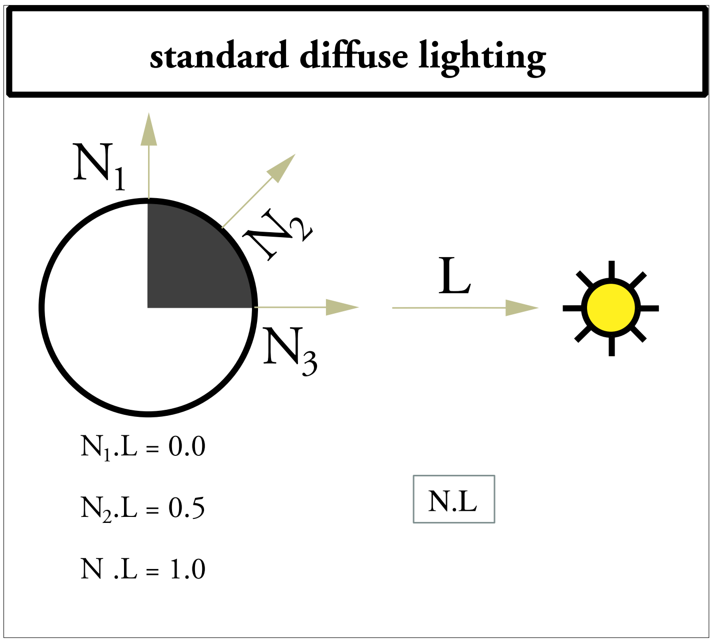
Since the script called for such a large variety of situations, robust and thorough lighting tools were developed to light Stuart as magically as possible. The artists and lighting TD's had a variance in background and training that afforded the shader writing TD's, mainly Clint Hanson, freedom to explore and add many controls never attempted at Imageworks.

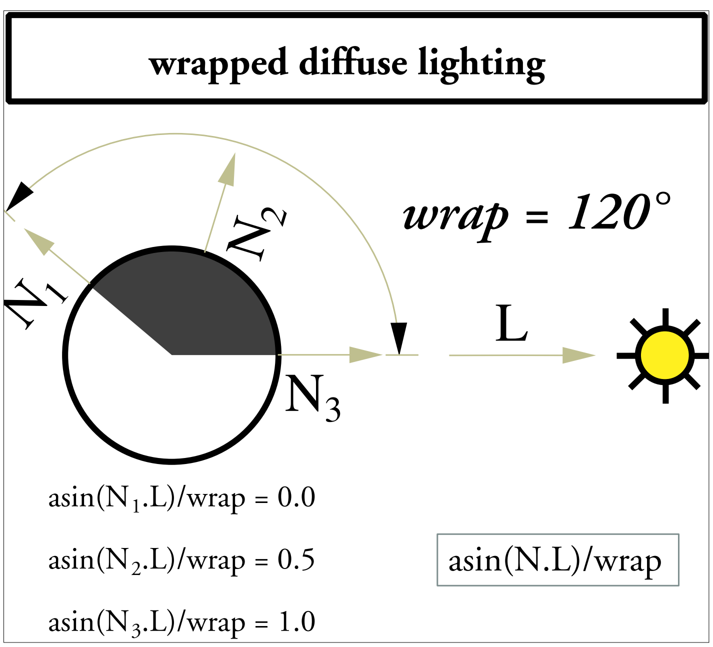
One thing was clear however from the first few lighting tests of the digital fur – the standard Phong and Lambert lighting models were not going to work for Stuart Little. The shadows were too rough. The diffuse falloff too rapid, the specular too harsh, etc.

Changing the lighting model

When a standard or traditional lighting model was used for the fur (essentially a Lambert shading model applied to a very small cylinder) many complications were immediately obvious. First, a diffuse model, which integrates the contribution of the light as if the normal pointed in all directions around the cylinder, leaves one side of the individual hair dark when oriented towards the light. While accurate, it does not produce images that are visually appealing. It is important to keep nature in mind here — getting outside and thinking beyond the CG box. It is important to understand what makes up a piece of hair. It isn't purely solid, or a geometric shell with a normal and UV space.

In the initial tests, the Lambertian model didn't produce the desired results of realism because much of the light that fur receives is a result of the bounce, diffusion, and transmission of the light off the surrounding hair to the next hair.





To truly achieve this model, some sort of global illumination solution would have to be invented and it would be very expensive. The time and resources for this did not exist. Consequently, the team pressed forward.

One of the most important reasons it was chosen to develop a new diffuse lighting model for Stuart's fur was that the default model was not intuitive for the TD's to light with, as it did not allow them to get predictable and desirable results. Mainly, it did not allow then to concentrate on being artists. Lighting TD's at Imageworks have developed very good skills at lighting surfaces and understanding the rules by which those surfaces behave. In that way, the new lighting model was designed to be lit in the way a TD would light any other real surface. The new model also made it easier to retain variation over the length of each hair. which was essential in getting the reaction of real fur.

In order to obtain a shading normal at the current point on the hair, the *surface normal vector* is mixed at the *base* of the hair with the normal vector at the current point *on* the hair. The amount with which each of these vectors contributes to the mix is based on the angle between the tangent vector at the current point on the hair, and the surface normal vector at the base of the hair. The smaller this angle, the more the surface normal contributes to the shading normal. A Lambertian is then used on the model to calculate the intensity of the hair at that point using this shading normal. This has the benefit of allowing the user to light the underlying skin surface and then get very predictable results when the fur is turned on. It also accounts for shading differences between individual hairs and along the length of each hair. It's almost as if however one lights the surface, the lighting "bleeds" right into the hair. It's not a perfect system, but it's 75% accurate, saving a lot of time.

For the wet fur, two aspects of Stuart's regular hair shading process are changed. First, the amount of specular on the fur is increased. Second, clumping in the shading model is accounted for. Geometrically, as explained earlier, fur is modeled in clumps to simulate what actually happens when fur gets wet. Rendered layers of specular, reflection, and environmental components would then be used later in compositing.

Calculated for each light, it's determined in the shading model what side of the clump each hair is on with respect to the light's position. This hair is then either darkened or brightened. The result is that the hairs on the side of the clump facing the light are brighter then the hairs on the clump facing away from the light.

In regards to optimizing the fur renders, a few things were learned by sheer experimentation. The level of detail requirements along the length of the hair were very low. The color along the length of each individual hair was kept constant, save for transparency. Detail was achieved from each hair having slightly different coloring. Stuart's fur didn't consist of many curves or sharp highlights, so a very high shading rate was used that simply allowed RenderMan to interpolate the shaded values between the samples. This substantially reduced the number of times the shader code needed to be executed, thus speeding up renders.

Interestingly, the pixel samples value ended up being quite high. Lots of very thin overlapping curve primitives without adequate pixel sampling aliased badly. For most every fur render, the pixel samples needed to be 7 in both directions. Different filters were tried, and it was determined visually that the sinc filter kept more sharpness and did not introduce any objectionable ringing.

Backlighting and Rim lighting: The 'essence' of Magic Lighting

To give Stuart his deserved look of "magic", it was necessary to have the capability of giving him a cinematic silver-lining or rim light that would wrap in a soft and natural way. CG lights are not known for their softness and subtleties.

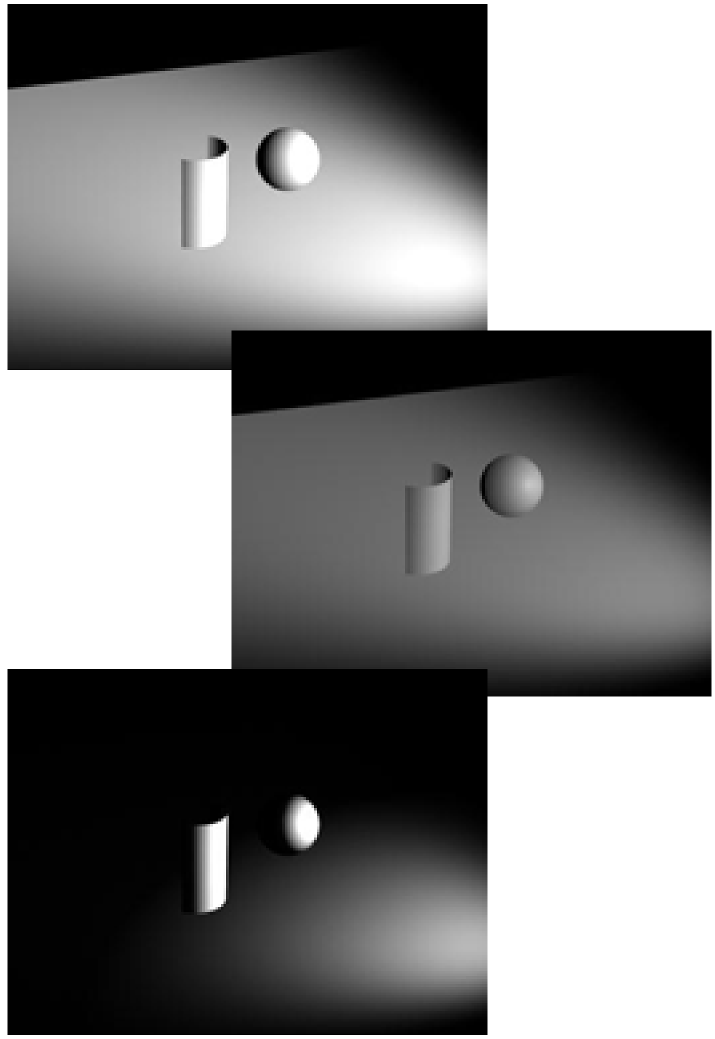
Many TD's who come from the stage, photography, and the set, are horrified to find that CG lights, while they don't get hot, are really quite primitive in their basic controls.

Because of this, special light shaders were written in conjunction with the fur shaders. Clint Hanson and I spent many hours and deep thoughts on how to achieve cinematic lighting controls, without bogging down the TD with shader parameters. It turned out that *lots* of controls were needed.

The key ingredient to Stuart's magic lighting was his rim light and silver lining. When viewing the film again, keep a special eye out for this, and you will see the rim light pop up in curious places. Ironically, though there may not appear to be a 'motivation' for a given rim-light, it works in most every scene. This is partly attributed to Guillermo Navarro, who was the films' Director of Photography. He happened to use a lot of hot rim lighting and small kicks off small objects.

During the course of lighting Stuart, he couldn't be treated any differently than any of the other actors Guillermo shot on screen. However, if he were lit 'exactly like the set' he would appear as a prop, with little magic. Stuart wasn't on set to be specially lit as the star. The goal in digital was to pop him out of the screen and give him magic, without being too obvious or contrived.

Since CG lights aren't typically soft and diffuse, the first step in generating nicely wrapped lighting is to give the light the ability to reach beyond the 90 degree point on surfaces of objects. This has the effect of softening the light on the surface, as if simulating an area light. The controls built into the Stuart Little lights had the ability to specify the end-wrapping-point in terms of degrees, where a wrap of 90 degrees corresponded to the standard Lambertian shading model. Higher values indicated more wrap. Though it broke all laws of physics, this control was natural for the lighting TD's to work with, and gave very predictable results. As many of the Stuart TD's come from an analog photographic background, many now wish they had these wrappable lights in their studio.



When putting these wrapped lights to practical use with shadow maps, multiple problems were encountered. Normally, the backside of an object will be made dark because of the shadow call. Naturally, this makes it impossible to wrap light onto the backside of the object, without getting a really odd and unnatural look.

Thankfully, RenderMan provided a few capabilites to get around this problem. One way to solve this problem is by reducing the size of the geometry used in the shadow map calculations. This results in the object continuing to cast a shadow, though slightly smaller in size compared to the original. This lets the areas that need to catch the wrapped lighting, not be occluded or shadowed by the shadow map.

Practically, simply shrinking an arbitrary object is not always an easy or straightforward task. Displacing the object inwards during the shadow map calculation is one option, however this can be *very* expensive and time consuming.

In the case of Stuart's hair, opacity controls were written into the hair shader. These controls were used to drop the opacity of the hair to 0.0 at a certain percentage of the way down each hairs' length. It's important to know, that the surface shader for an object is used during shadow map calculation. If you set the opacity of a shading point to 0.0, it will not show up in the shadow map. The value which is considered "transparent" can be set with the following rib command:

Option "limits" "zthreshold" [0.5 0.5 0.5]

Lastly and most simply, by blurring the shadow map when making the "shadow" call, soft shadows can be achieved. This blurring allows for the falloff of the light to "reach or wrap around" the object. If there is any occlusion caused by the shadow, it will be done so softly, creating a smooth, nice effect.

For Stuart Little, a combination of shortening the hair during the shadow map calculations, and blurring the shadows, allowed the appropriate amount of wrap to be added and controlled. This method proved to work throughout the entire film, and provided the Supervisors, TD's, and lighting artists with intuitive and understandable controls. The rim lighting technique is essentially the basis for Stuart's "magic" lighting treatment.

In addition to his strong key-to-fill ratio, great care and attention was paid to light levels, both visually an numerically, and to the rest of Stuart, so that there was always visual and numerical room to add Stuart's rim light without blowing him out. This rim effect popped him out of the screen, gave him a dramatic look, and sealed him to the background plate in the compositing stage.

Textures as Means for Control and Exposure

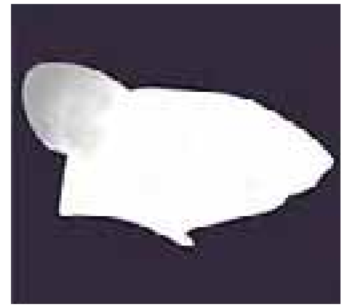
As important as the fur itself was the skin underneath it. Though most of the head was covered in fur, Stuart's ears, nose, muzzle, tail, and hands all showed young skin underneath. A standard lighting and shader approach, such as a typical Lambert diffuse model, would again not be sufficient for realistic flesh.

A complicated yet controllable system of shading parameters was developed and matured over the entire course of production. Texture maps, or "exposure maps" were painted in StudioPaint 3D, then called in the shader to perform various functions. All in all, over 25 different layers of exposure maps were created for each character to give the artist the proper and detailed control necessary for realistic lighting.

One area of great focus was Stuart's ears. Since he was young and of course cute, the need for seeing his peach-fuzzed covered fleshy ears arose. Stuart spent a lot of time in front of lights, windows, doors, and bright people. And because he was being treated with "magic" lighting, a la the rim light, the flesh in his ears, nose, hands and even eyelids needed to transmit light and "glow", depending upon their orientation to a given light.

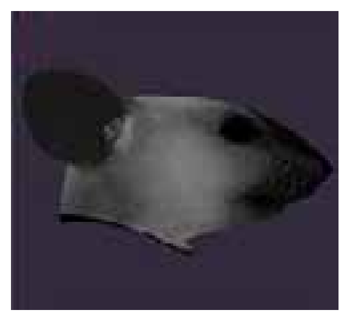
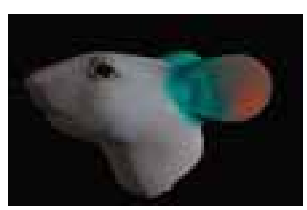
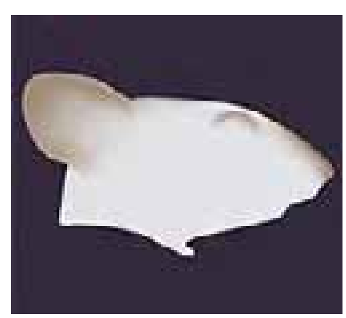
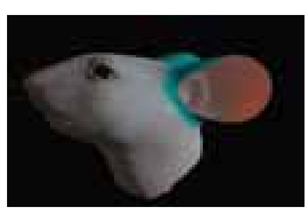
Exposure maps were created to control different areas of the ears. These maps in turn were used inside the skin shader to control how bright an area would become, how reactive to light that area was, and which color that area would become. Clamping and cutoff controls were even written into the shader to avoid any deep blacks. These blacks would cause Stuart to look dirty and possibly diseased. Again, anything that got in the way of his 'cuteness' was dealt with rapidly.

Exposure maps were created to control dozens of areas. This was necessary to gain control of the details of each character. John McGee was on from the very start, working mainly in StudioPaint 3D, making changes almost daily in the beginning, then tapering off over the show. As luck woud have it, there were times that required special texture attention and a special set of maps for one scene alone. Handling these different versions of textures and shaders was dealt with through a complex system of versioning and publishing.







Some of the types of exposure maps created were as follows:

• Hair (including separate sets of maps for head, hands, tail, feet–for 3 characters)

opacity, transparency
wave
color
color variation
density
length
whisker maps
clump
clump area
clump size, rate, percent
guard hair
guard hair length
guard hair density

• Skin (including separate sets of maps for head, hands, tail, feet–for 3 characters)

colour
specularity
bump/displacment
environment
glow/falloff
organic noise
whisker marks/freckles

• Eyes (for 3 characters)

specular
reflection
color
bump/displacement

Lighting in the "real world"

Lighting Stuart with *magical qualities* started off in a similar way the team approached everything else– with reference. Films were viewed, stock images were downloaded, even images from the TD's themselves were all compiled, viewed, discussed, and put on Imageworks own Stuart Little intranet web pages.

In the training department, lighting classes and techniques were held with real lights and real objects, so that all the artists could see and experience first hand the way natural light reacted. Unfortunately all is not so easy in the CG world. New lighting tools were invented, new shaders coded, and new controls written, all to mimic and often-times improve upon reality. In CG it would be nice if a bounce card could simply be thrown up in 3D space to reflect light, but conversely in the real world, you can't exclude a light from casting shadows. The battles must be picked carefully, and *reality must be understood* in order to outdo it.

Reality is where it all starts. At the beginning of, and during the show, dozens and dozens of reference images were taken. These images were used until everyone gained enough skill and experience to do it on their own. The artists got so good at lighting Stuart and the Stouts toward the end of the film, most reference, including the references shot on stage, were not even looked at. Everyone got to know Stuart, how good he looked, and how much magic he deserved. Though it might sound rather corny, Stuart really became and entity to the crew and to the studio. When a TD lit him, it was with care, respect, and the real desire to make him look like a *star*.

He was as real as anything.

Your eye is your camera, your brain is your film.

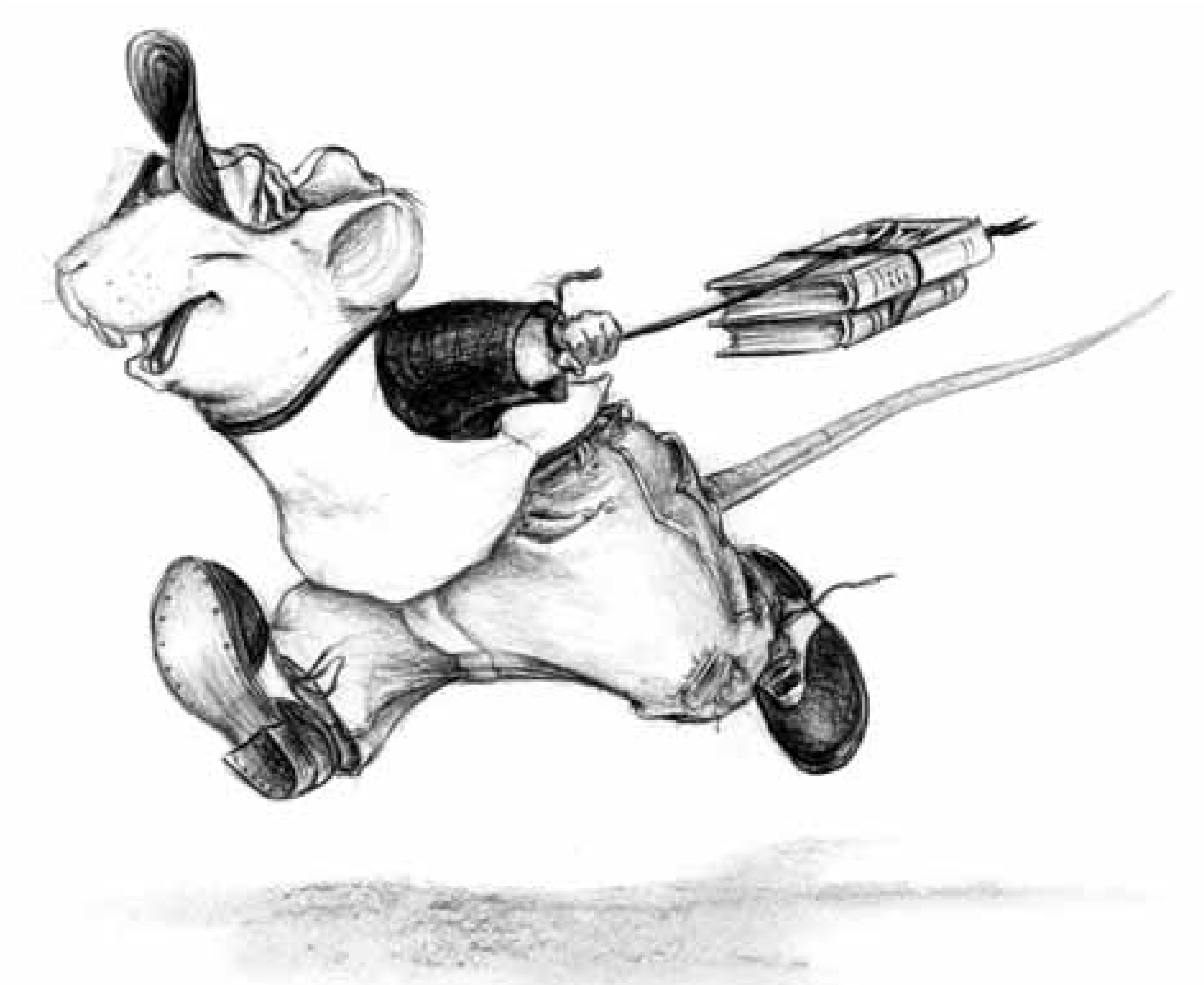
Acknowledgements

Film and/or Course Note Contributors:

Armin Bruderlin, Clint Hanson, Alan Davidson, Bob Winter, John McGee, Rob Bredow(who wrote the *kewl* software that produced the mosaic below), John McLaughlin, Rob Engle, Stuart Sumida, Bruce Navsky, Kevin Hudson, Robin Linn, Barry Weiss, Sande Scoredos, Eric Armstrong, Peter Nofz, Thor Freudenthal, Todd Wilderman, Amit Agrawal, Steve Prawat, Josh Abrahms, Jim Stenroos, Jason Clark, Jacquie Barnbrook, Rob Minkoff, Don Levy, Amy Adams, Lincoln Hu, Ken Ralston, John Nicolard, Michael Moore, J.W. Kompare, Cyndi Ochs, Mickey Levy, Rich Cole, Nikki Bell

And special thanks to:

E.B. White for writing such an amazing book about an inspirational 'little' character. Columbia Pictures for even daring and trusting in Imageworks to make this film. All the artists, technicians, TD's, and production crew, for putting their heart and soul into every image on screen. To the Imageworks model shop, Thuderstone — you will be missed. And to José Luis de Juan, for putting up with me over the 2 1/2 years of the making of this film. To all — Don't forget, sometimes reality is *boring*!



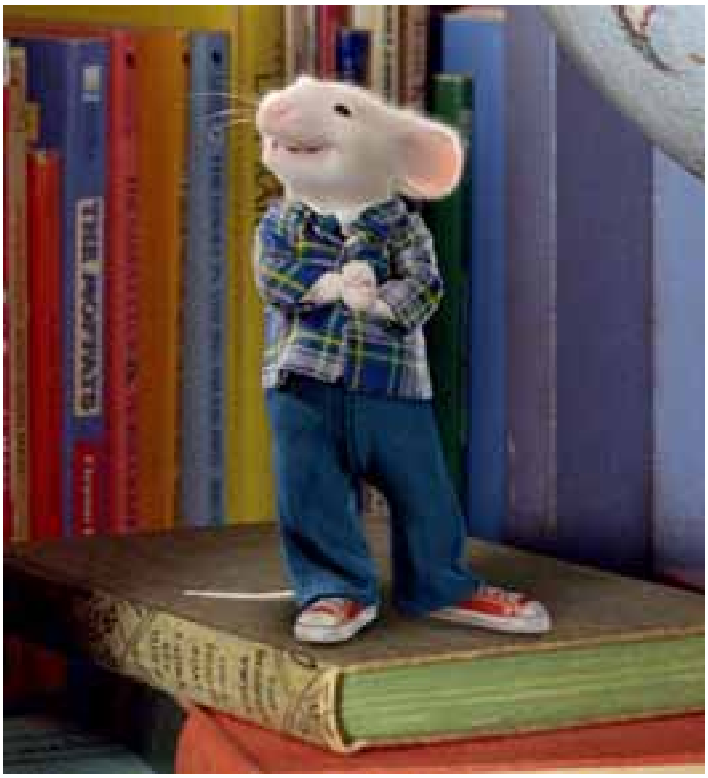
Course #14, SIGGRAPH 2000
New Orleans, LA, USA

Stuart Little: A Tale of Fur, Costumes,
Performance, and Integration:
Breathing Real Life
Into a Digital Character

Costuming and Cloth

Jim Berney
Sony Pictures Imageworks, Culver City, CA

Costuming



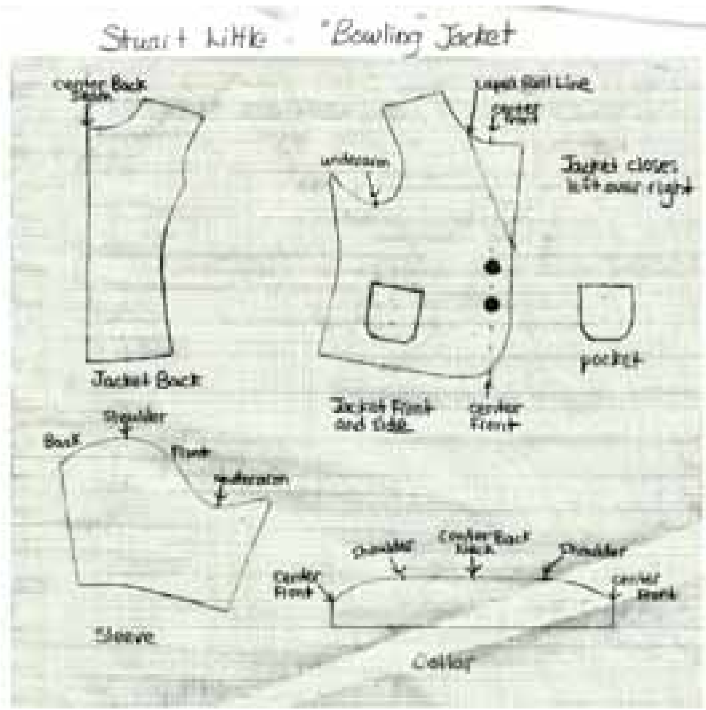
The cloth team was responsible for all aspects of the cloth development from tailoring to animating. Because the digital costumes would be seen side by side with the live action costumes, the cloth had to look and move as real as possible for our digital characters to be believable. This required the costumes to have every bit of detail as a real life costume, including collars, cuffs, pockets, and buttons, as well as creases, seams, and zipper flies. It also meant the costumes had to fit properly, because the way a costume fits a person will define the character, and it had to move correctly, whether the character was standing still, walking, running, sailing a boat, or swimming underwater. Knowing the characters would be seen up close, revealing every detail, the fabric had to have texture, weave, and fuzz. In order to meet the needs of a production schedule, the pipeline we developed also had to be robust enough to support 13 costumes for 3 characters, and for 500 plus shots.

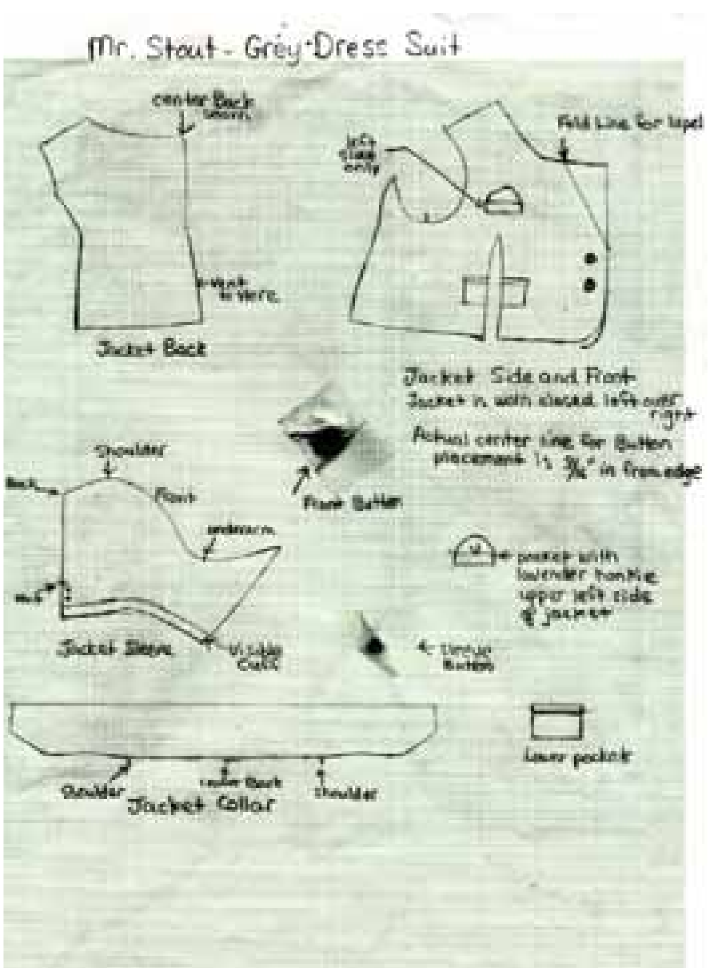
But most important, the costumes could never limit the animation of the stars, Stuart, Reginald, and Camille.

Tailoring

Because how a costume fits a person ultimatly can define that person's character, tailoring was a critical step in the cloth pipeline. For example, given the same Stuart model, if the costume was baggy and hung off his body, Stuart would appear to be shorter, fatter, and perhaps a bit younger. But if we tailored the costume to be snug and tight, he would appear to be slimmer, and older. Although final control of the tailoring fell into our hands, the design proccess was initiated by a traditional costume designer.

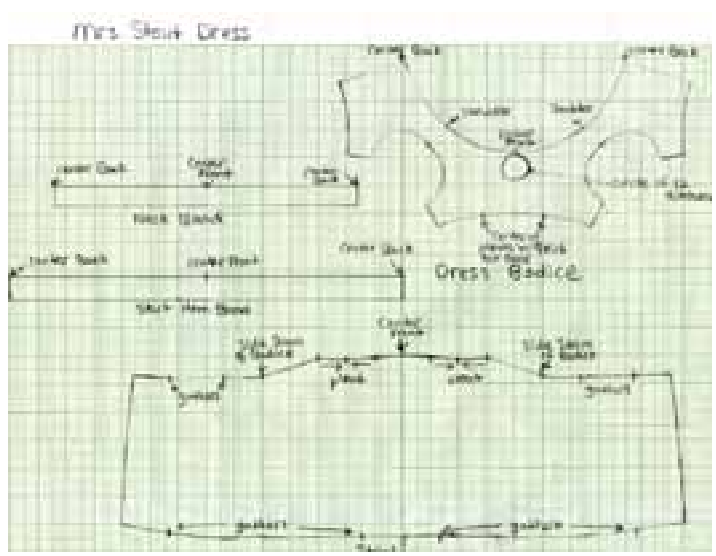
Our approach to designing the costumes paralleled that of traditional costume designing techniques. The costume designer would sketch out designs for various costumes, for various occasions, and the director would approve which costumes he felt best fit the characters. Based on the sketch, miniature patterns were created and sewn together the same as any life size costume would be built. We would take these patterns and scan them into the computer to be used to model the panels that would make up the costume. Using the Maya cloth plugin, and the Davey Fashion Designer or DFD created by David Allen, these panels were stitched together to build the costume.





Cloth Dynamics

This was new territory for Imageworks, and we knew the requirements for animating the cloth would be many. It had to be quick, easy, and require only a few hours of work per shot. Continuity had to be maintained within a shot and from shot to shot. The cloth had to move naturally, and be affected by gravity, wind, and friction. Ideally, everything needed to be as automatic as possible, yet allow for multiple layers of shirts, vests, and jackets. It was apparent that traditional methods of animating could not meet our requirements. The costuming for "Stuart Little" clearly needed a dynamic solution. The animation team decided to use Maya for character setup and animation and it was to our advantage that Alias|Wavefront was in the process of developing a cloth plug-in for Maya. Although the the plug-in was still in the alpha stage of developement when we first started production, it offered us the opportunity to create our own tools around it, building a pipeline which would enable us to work within the methodologies outline above.



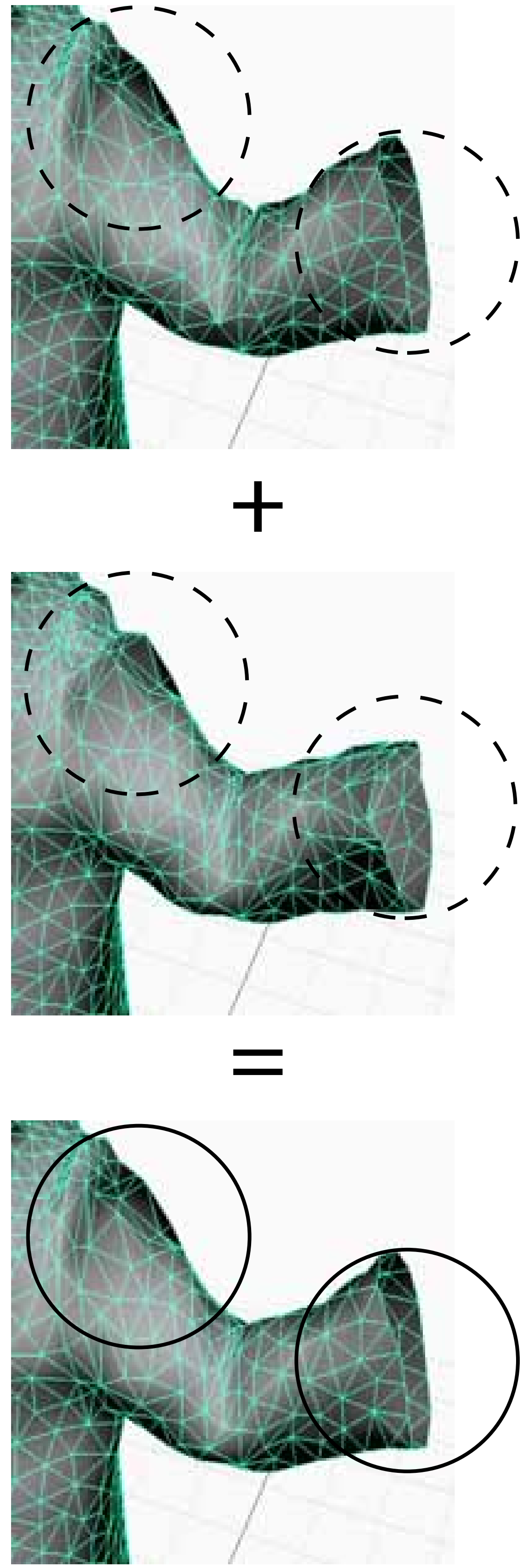
Cache Blending

Sometimes it was difficult to achieve the desired movement of the cloth with the character's animation. Often during long simulations, a portion would run successfully while another portion would render undesirable results, or fail completely. By using the Houdini cache reader/writer written by Rob Bredow, a tool was created by Matt Hausman to blend caches of different simulations together within Houdini. By doing this, we could save the successful frame ranges from one simulation, while focusing only on the ones that failed. For example, we could use frames 1 to 100 of one cache, and frames 90 to 200 of another. This way, some parts of the animation never needed to be re-simluated.

Cache blending could also be used to blend specific areas of the costumes together. For example, we could take the shoulder area from one cache and blend it with the shoulder area from another cache to achieve the desired movement. In this way a simulation of the full frame range could still be used. Only the very specific areas would need to be re-simulated.

In addition to blending multiple simulated caches together, we also used non-simulated passes, or "physiqued" passes for blending. The "physiqued pass" was created by Sho Igarashi using partial weighting to produce a non-dynamic costume that moved along with the character, but contained none of the costumes physical properties. This pass was used when the characters pose or actions made it impossible to obtain a good simulation. For example, when Stuart was sitting in a chair his lap became pinched, rendering a mass of crumpled cloth. In this case, however, a good torso simulation would not have to be dynamic. Only the sleeves and pant legs would have to move and be fully dynamic.

With these various blending techniques the caches could be used back to back, or mixed and matched, as long as the resulting caches were in the same animation setup for a given shot. It was then fesible to take as many cloth caches as we wanted and mesh them together. These caches could be partial frame ranges, contain different dynamic properties, or have specific successful areas, regardless of how the rest of the costume looked.



Noisy Cloth

The next challenge was to eliminate what we referred to as "noisy cloth". This is where an area of the costume would become unstable and vibrate randomly. There were two causes for this. Because of Stuart's size, the scale of the costumes were smaller than what the tool was originally intended for, requiring very stiff properties. This sometimes caused the cloth to resist the movements or poses of the character. To get rid of this type of noise we read the costume's cache into Houdini where we would then filter out the noise using vertex averaging.

Another cause of "noisy cloth" was the collision body itself. Sometimes if the bend in a joint became extreme, the NURBS body would fold in on itself, causing the cloth to become pinched, or trapped. To remedy this, a polygonal version of the collision Stuart body was created to be used for the cloth simulations.

Laser Polys

"Laser polys", or stray polygons, would often shoot off in a different direction than the normal, creating what looked like a laser shooting out from the costume. This problem usually occurred when the cloth reached a state where it was severely crumpled and the method of thickening the edges was unable to deal with it. Extruding the visible edge of a garment in order to thicken it would cause this artifact to occur in a frame or occur several times throughout a shot. A solution to the "laser poly" problem was needed immediately. A tool was created to detect if a stray vertex had shot off and, if so, the tool would bring it back by scaling the point to the interior of the garment. Since the vertex was crumpled upon itself within the area where the "laser poly" originated, scaling the vertex to the interior of the garment rendered the stray poly invisible.

"Wind Effect"

In sequences like the Boat Race, the cloth was required to move as if affected by wind. Often it was a challenge just to simulate the costume *without* this effect. This added more difficulties to an already difficult process. Because it was required to see many iterations before getting a desired wind look, it was decided to simulate the costume without wind, and later add the effect as a post process.

Matt Hausman created a process where the cache was read into Houdini, and the wind effect was made by passing the vertices through a noise field. Although the cloth would move with complete disregard to the characters body, causing some interpenetration, the cloth was rendered separately from the body, and this would not be noticable in the final composite. This proved to be a quick and reliable solution.

Adding Detail

While the cloth objects are all polygonal, the detailed attachments to the garments were accomplished with NURBS geometry, which provided a higher level of detail and ease of modeling. While the MAYA Cloth Plug-in creates basic garment shapes, it is difficult to achieve a desired look and it takes too long to model details, such as collars and cuffs. Since the attachments to the garments were incredibly detailed, the methods used to create these needed to be robust. Polygonal garments with polygonal attachments were unstable and tended to explode. It also took longer to achieve the desired movement and simulations took too long since the polygonal objects needed a higher level of tessellation.

Collars

The NURBS collars were modeled and attached to the polygonal garments and provided fast and robust simulations. To create the NURBS collars, a curve was drawn on the 2D pattern layout where the NURBS object existed. For the collar, a curve was drawn along the edges of all the panels that related to where the collar should exist or extrude. A control vertex was needed in this curve for the cross section, and later used for the loft. Each cross section would provide the control needed to shape the NURBS more to fit the design. This curve was then drawn on the 2D panels and drawn onto the geometry of the related garment's panels. The 2D curves, panels, and garments were all historically related in some fashion. The result was a curve that was attached to a garment. This curve could also be extruded along by creating a number of cross sections that correlated with the number of control vertices on the surface curve. These cross sections were extruded along the surface curve using one of our proprietary plug-ins. The collar would then miraculously appear, with normal facing in the correct orientation along the path that was calculated during the extrude. The collar would then rest along the garment.

Although the NURBS collar was able to move with the cloth, there was no interaction of the NURBS with the other cloth and hand tweaks were sometimes needed to correct any interpenetration. In addition to collars, the same method was used to produce the cuffs, pockets, and ties with knots.

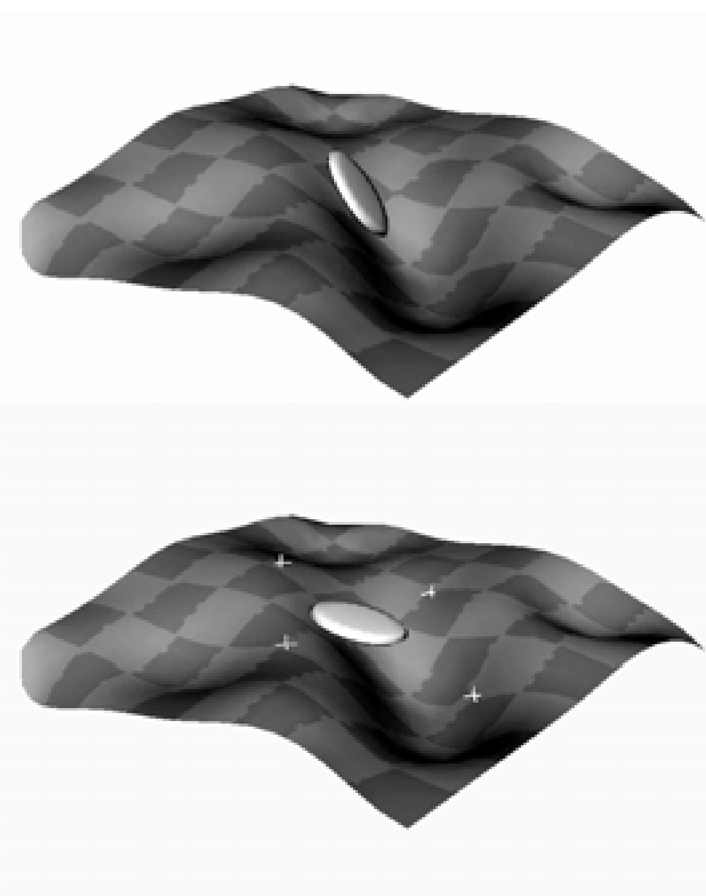
Piping

The pajamas and the sailor suit both had extensive piping details. Mike Travers achieved these details by lofting a curve around selected panel edges where the piping needed to be.

For instance, the cuff of a sleeve would be paneled by having the actual cuff as a set of panels, and the rest of the sleeve as separate panels. This produced a boundary between the cuff and the sleeve body. By selecting the cuff boundary that coincided with the sleeve body, a path was created to extrude a cross-section. This created NURBS geometry on the resulting garment, which would then correlate with the boundary edge on the 2D panels and create a new generation of piping.

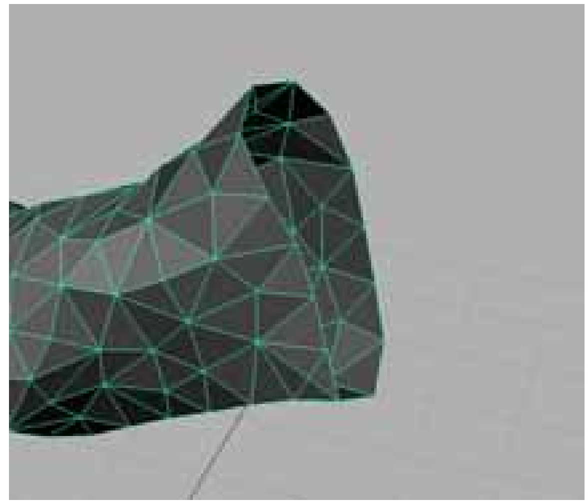
Buttons

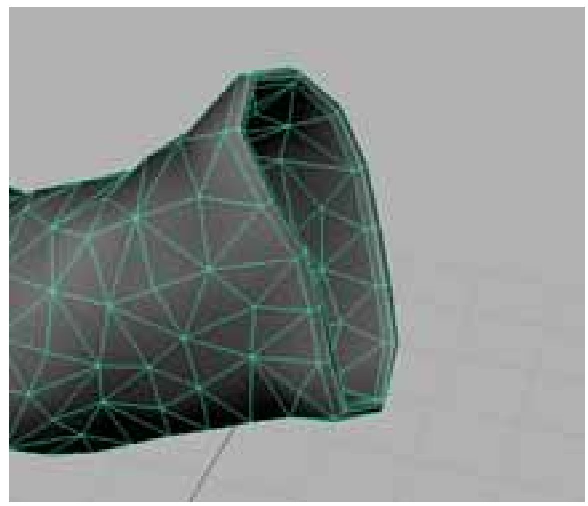
Buttons were attached to the garments using point constraints. The orientation of the buttons was achieved by averaging four selected outside points on the button. Problems developed with the normal orientation in situations where the cloth around the constrained point was crumpled and the normal would radically change and cause a button to flop around. Dave Allen developed a tool that would select the outside points from which the orientation of the button was derived. It would then average the four points and the constrained point. Typically, we would select four points in a cross pattern that were immediately next to the constrained point-to-be. As a result, the button would then change orientation. Using this technique the button's orientation was less likely to change radically frame by frame, creating a more stable button.



Thickening

The last bit of geometric detail added to the costumes was the "thickening". This was a process developed by Mike Travers to add thickness to the costume. This was achieved simply by extruding the geometry inward. The edges of the geometry were then beveled so they wouldn't appear squared off in the render.



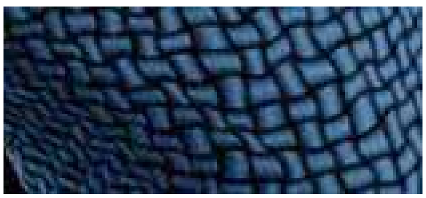


Rendering

The easiest approach to rendering cloth is to apply texture maps to the geometry and render with standard illumination models. Unfortunately, this rarely looks any better than what you'd expect. In the case of Stuart, where the cloth was viewed on such a "micro" scale, we had to design a cloth rendering technology that would:

1) Fit the Imageworks RenderMan pipeline.
2) Be capable of showing the thread level of detail of the cloth and still exhibit "macro" characteristics from a distance.
3) Be flexible enough, allowing us to design multiple outfit looks with a minimum of technology re-design.

Weave and Grain



Since we had to show thread level detail, one of the core technologies developed by Josh Kolden was a “weave” pattern to emulate threads without actually modeling individual ones.

Within RenderMan, a simple antialiased tile pattern was modified to portray the over/under pattern of threads weaving.

Rows and columns of this tile pattern became (conceptually) “threads” to which we could add a rolling displacement across the thread. While this proved adequate for general lighting cues on the thread surface, an additional concept of “grain” was developed to enhance the lighting effect.

The cloth in the images to the upper left have some thread height, so it does have some shading based on the thread. The grain effect enhances the “valleys” of the thread adding “tooth” to the material. It adds detail that the normal lighting model could not achieve and can be dialed in based on the needs of the material and shot.

Below, it is applied to Stuart’s khaki pants. By darkening the “grain” of the pants, we pick up more of the thread weave and change the coarseness of the material.

Additionally, since each column or row of our tile can be thought of as an individual thread, we can introduce a certain amount of thread-to-thread variation that ties the weave together and adds a more natural feel to the material. This was particularly effective at smaller screen sizes where the thread weave was too small to detect, but the thread variation was still apparent.

Scale issues

This brings up another obvious, but often overlooked issue, the look of the material at various screen sizes. While a material look may be dialed in based on a select “beauty shot”, it will be used in a variety of scales and lighting conditions. To address this, it is often a good idea to have custom versions of materials pre-made for these conditions. An example in Stuart was the sailor outfit. The standard material for the sailor shirt is shown to the right. The “close-up” version is below right. What is the difference? The standard material uses a larger thread pattern and more variation to “read” better on distant to medium shots.

Fuzz and rim lighting

Another significant aspect of cloth is “fuzz”, the sort of soft glow created by the fibrous materials of thread catching light from many directions. In a tightly woven material, fuzz is mostly apparent in rim lighting where a soft glow appears on the edge of the material. In a looser, fuzzier material (such as Stuart’s pajamas), fuzz would not only be apparent in the rim, but also throughout the surface. To accomplish the basic fuzz look, Mark Lambert began by modulating the diffuse lighting with a fractal noise pattern ... one designed to give just the right “clumsiness” for the fuzz. We then modified the lighting model so that fuzz was only added in a “grazing” area of a light. For instance, if a light was directly behind the camera, you might see little fuzz; but if that light was moved 45 degrees around the cloth, then the front surface would begin to “glow” with the fuzz.

The effect of rim light was also enhanced with this same fuzz. Special controls allowed the material designer to control how much fuzz was in rim light and also to attenuate it with the thread weave so that it was not consistent across large threads. Rim lighting also took a "grazing" concept into account. In essence, we reflected a ray from the camera off of the material and then used that direction to make our lighting calculations.

Additionally, controls were added to the materials and lights to allow the lighter to "wrap" the rim light wider or tighter around an object.

Together, these controls allowed the lighter to "sculpt" the edge with a soft glow that created one of the main illusions of cloth.

Displacement and Procedural Wrinkles

While the cloth dynamics system allowed a gross level of folding and wrinkling, we found it necessary to accentuate this with shader-based wrinkling as well. A few simple noise functions made it look like you forgot to iron your clothes *(actually, there is a certain amount of reality to that by the end of 500 shots)*. We found that two levels of wrinkle control worked best. There was a "gross" level that broke up large areas and helped add natural bulges and bends to the fabric and was a very soft noise pattern. A finer noise pattern with sharper detail was also used on some outfits for additional detail. While these were not dynamic in nature, they were convincing as long as they were subtle enough, and helped even in long shots to break up lighting.

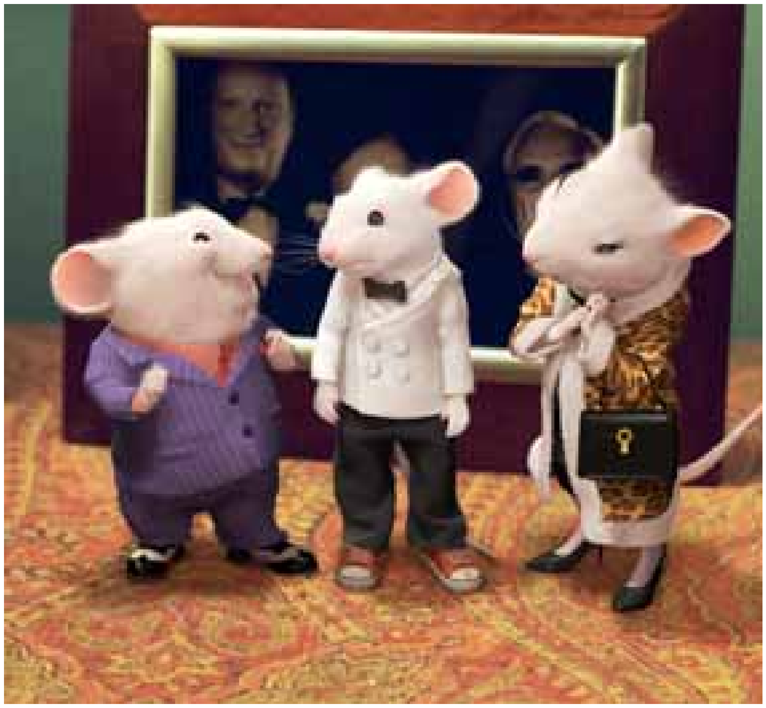
Creases and Seams

Displacement maps were also used for such things as seams and creases in the outfits. Similar to the thread grain, additional controls were added so that fake shading could be added to these areas.

In the case of seams, a darkening at the seam point helped sell the break in the fabric. In the creases, we had a function to allow us to control how "sharp" the crease was in the displacement. Interestingly, no matter how sharp/soft/deep we made the crease and then lit it, something didn't feel right until we added a small white line drawn onto the crease. After looking at our ironed pants it hit us, *don't forget the wear and tear*.

Acknowledgements

Mike Travers, David Allen, Sho Igarashi, Rob House, Doug Yoshida, Matt Hausman, Rob Bredow, Allen Ruilova, Hector Tantaco, John Lee, John Ly, Mark Lambert, Joshua Kolden, Alias|Wavefront



Course #14, SIGGRAPH 2000
New Orleans, LA, USA

Stuart Little: A Tale of Fur, Costumes, Performance, and Integration: *Breathing Real Life Into a Digital Character*

Matchmoving , Compositing, and Effects

Scott Stokdyk
Sony Pictures Imageworks, Culver City, CA

Matchmoving

A matchmove is the reconstruction of the placement and attributes (focal length, aperture, etc) of the real camera used to shoot the plates for a scene, and the lineup and placement of the 3D geometry representations of real objects in this camera view. It is also called 3D tracking.

After a 3D camera and geometry are created, they are passed onto a shot setup person, who places the 3D models of characters and objects in the scene for the character animator. This allows the movement of the character and their props to match the perspective of the background plates that they are composited over.

General Overview

A Stuart Little matchmove (track) could contain one or more of the following elements:

- **a camera track**
- **a rigid or hard body track**
- **a soft or deforming body track**

Rachel Nicoll organized a group of about 11 matchmovers to complete all these elements for approximately 500 shots.

The matchmoves on Stuart Little could be classified in these five increasing levels of difficulty (easiest to hardest):

1. Locked camera & objects only. An example of this would be a locked off shot of just a floor (a rigid object) with no moving or deforming objects.

2. Moving camera with only a couple of hard objects in a scene that are not moving at all. For example, a camera move across a tabletop.

3. Locked camera with hard moving objects. This happened occasionally in car chase scenes, or for a moving suitcase floating in water.

4. A locked or moving camera with some soft deformation. For instance a moving bedsheet or clothes bouncing in a washing machine.

5. Moving camera and a moving focal length on the camera with a hard or soft object track. A good example of this would be when Stuart was picked up in a hand and carried around.

Prior to Stuart Little, matchmoving at Sony Pictures Imageworks had been done in Softimage and then exported to the other programs being used, i.e. Houdini or Alias. When Stuart Little started, the decision was made to do the matchmoves in Maya, because it was being used in most other aspects at the head of our pipeline. There were various custom SoftImage matchmoving plugins that had to be ported into Maya by David Spencer, Charlie Clavadetscher, and our software department.

Models, Set Info & Transit Data

We were very fortunate to have early input on the design of the set. Charlie Clavadetscher consulted with the set designers to make sure we had floors with checker patterns, nice sharp corners in furniture and wallpaper patterns that we could track. Even little things like putting square designs on the bed sheets made it easier for us to get a good camera track. Because of production's cooperation we were also allowed to add tracking markers to the set that were then painted out later.

There were two matchmovers on set (David Spencer & Joseph Thomas), one for 1st unit and one for second unit. They made notes on dimensions, put down markers and photographed our lighting reference balls and the Stuart stand-in maquette. During both the set preparation and shooting we surveyed the set to get all the data we could, including the dimensions of objects, distances from the camera to the ground, and the distance from camera to some of the key objects in the scene.

Back at Imageworks, we had a licensed architect on staff, Alex Whang, who built our virtual 3D sets from both architectural plans and measurements taken from the actual physical sets.

By using a combination of manual and procedural processes we were able to reconstruct objects for tracking. Later in the pipeline, a lot of these objects ended up being shadow casting or shadow catching objects. Alex Whang modeled most of the props or additional items beyond the sets themselves, including the suggestive peanut.

It was important to have the sets built before starting the sequences so that the matchmovers would be consistent in their placement in space. This way lighting setups could be easily reused for all or most shots in a sequence. This consistency also made it easier for other artists down the line to work with the match moves.

Taking reference photos around the set from different views facilitated this process. Photos could be used later as environment maps and reference photos for those CG artists who were lighting shots. In some cases these photos were also used for photogrametry, which allowed us to reconstruct 3D objects from 2D images using Photo Modeler Plus. We did not end up doing any 3D scanning of any objects.

Hand Matchmoves vs. Procedural

No markers were put on the actors hands, but a lot of effort was put into providing the info to build the hand models. They were photographed with a wireframe or crosshatches projected on them, and plaster casts were also taken to get a good basic 3D model.

It was decided that it would be too much work to paint out markers on the hands, so they had to be matched by eye using logic regarding the movement and flexibility of the human hand. This proved to be one of the more difficult types of matchmoves we had to do on the show.

The boat race seemed like it would end up being a very hard sequence to complete. Unlike a car or any object on solid ground, boats are capable of a great deal of subtle motion. Granted the boats were on tracks, but there was still a lot of play in their motion.

Luckily, a couple of programmers (Tasso Lappas and Sam Richards) on another Imageworks show called Hollow Man had been developing a 3D tracker that worked within Maya, and it was ready for testing when the boat sequence came in.

First we 2D tracked points on the boat with our in-house 2D tracker. These tracks were saved as curves, and then imported into Maya via our 3D tracker, named the Magic Tracking Thingy (MTT). The tracks were assigned to vertices in the models Alex Whang built of both the 1:1 and 1:1.5 boats. Most of the shots that were done this way finaled on the first try.

The MTT also proved to be a lifesaver for the scenes of the film's finale that took place in the trees of Central Park.

One shot in particular had a very intriguing history, HS1, which unfortunately was cut from the film before completion. It was a helicopter shot of the miniature golf park that the Stouts lived in. The plate consisted of a zoom from far away into the space under the Brooklyn Bridge. Dan Ziegler first tracked it in 3D Equalizer which did not require any data about the shot. The 3DE file exported to Maya had no camera data, but only point cloud data, which gave Dan an idea of where the structures were in the plate. He added basic geometry such as boxes and planes, then used MTT to fine-tune the camera move.

Matchmove Check-ins

A big problem in the initial stages of the matchmove work was that the files were not consistent in structure, i.e. camera name & setup, file units, etc.

Initially we provided the matchmovers with a paper checklist before releasing the file, until one of our setup artists, Peter Nofz, came up with a better idea and wrote a MEL script to handle this.

It checked all the requirements, baked and locked the camera, saved out a new file, and sent out email. Among these requirements were things like frames per second settings (24 fps), camera overscan values, clipping planes, and scaling controls.

The artist could also indicate whether the shot was temp or final. Often an animation schedule would be released that required a matchmove to be available that same day. Since the animators started by blocking their shots, a reasonable matchmove was often good enough for that purpose. The matchmovers would rough out the shot and release it using then publishing system so that the animator would not sit idle. As the matchmove got fine-tuned, further temps could be released, until the final, approved by a computer graphic supervisor, was sent out.

Scale was another important matchmove issue. We would always try to match the real world scale format in centimeters because that is what Maya's native format is. We converted all set measurements to centimeters whenever possible. In some situations we had to scale our character to work in the shot. However, we would never scale the character because we had too many fur and cloth simulation parameters that were based on one scale for the mouse. We would scale the whole world around the mouse instead.

Pre-visualization

Pre-visulization is an increasingly popular technique, where camera moves are designed using lores geometry representations of the set to be built. Whole sequences can be blocked out in the computer that assist with set design and camera placement during shooting.

The majority of the pre-visualization work done for Stuart Little surrounded the boat race, cat chase, and opening sequences. Because of the complexity of the boat race sequence, and the great expense of shooting a number of shots in a large, water-filled tank, it was decided to use pre-visualization.

There were two basic aspects to pre-visualizing the boats. The first was to provide a representation of each shot to the director and editor, allowing them to cut together the entire sequence before a single frame of film was exposed. During the course of the pre-visualization process, shots were changed or cut based on the pre-visualization animation.

This allowed the directors the creativity to design the sequence, beyond storyboard level. It became apparent early on that fast turn-around of animation changes was needed to keep up with the demands of the director and editor. Between 2 pre-visualization animators, Andrew Titcomb and Rachel Nicholl, dozens of iterations of shots would be submitted on a daily basis.

The second useful aspect to pre-visualizing the boat race sequence was to plot out the camera and boat moves for each shot. All the pre-visualization data was provided to Eric Allard's team, who was able to then build the tank that was designed, based on pre-visualization. Each boat traveled on underwater tracks, which were constructed from the pre-visualization plans.

With each shot, the crew was prepared with all the information they needed, from boat placement, speed, and direction, to camera placement, motion, and lenses. A tape of the pre-visualization was used as reference, as each shot was filmed.

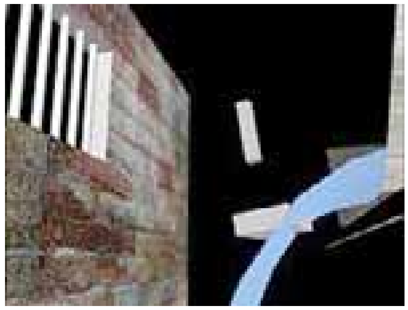
John Dykstra was very clear and up-front in the beginning about what he expected from pre-visualization. He did not expect detailed rendering so wireframe and flat shading sufficed. The important things to him were to plan out every detail of each shot.

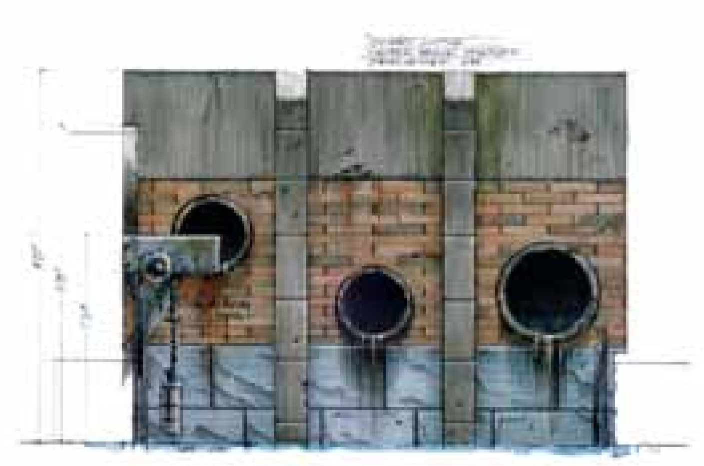
The scale of the boats was a major concern. John quickly discovered that larger-scale boats were needed for certain shots, because pre-visualization showed that they were necessary to achieve the look and angles, mostly from water level, that he and the director wanted. The direction the boats traveled and the direction of the wind was always a concern to maintain continuity.

With only one backdrop wall on the tank set, it was necessary to plan out how to give the impression of viewing the sequence from 360-degrees. Everything was created to scale, including the Super Techno Crane model, to match what would be used on set. We didn't want to design a shot that would not be possible with the equipment and set available.

After completing the boat race pre-visualization, we began work on pre-visualizing the cat chase sequence, which mostly occurred in the sewer.

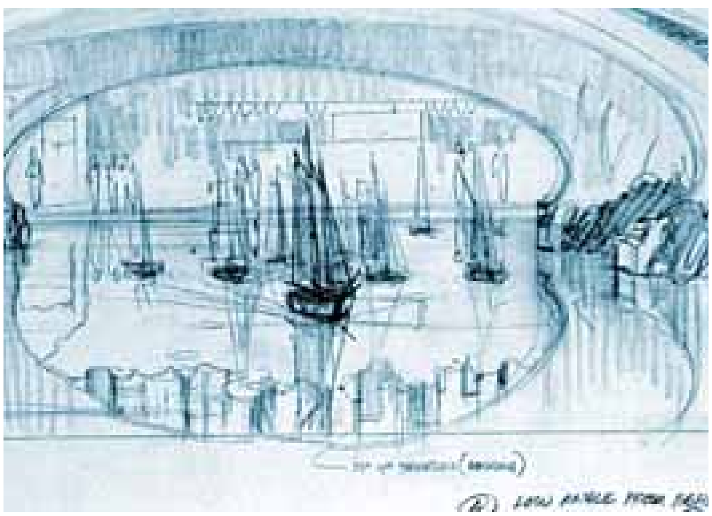
Plans for each set were provided and digitized. As with the boat race, John was able to place the camera, decide the lens type, and create animation timings that could then be applied directly to the stage. For some scenes, it was easier to use the computer to map out the action for the model car driver, cat trainers, and camera crew, than it was to explain John's vision.





During the shooting of the cat chase sequence, pre-visualization was moved to the stage to be available to John Dykstra, and provide him with an efficient means of preparing his shots. Pre-visualization allowed John to approach the task of shooting a variety of scenes with everything pre-determined. The speed with which the camera rises, and how fast the taxi drives away in the opening scene, were all known and approved long before shooting.

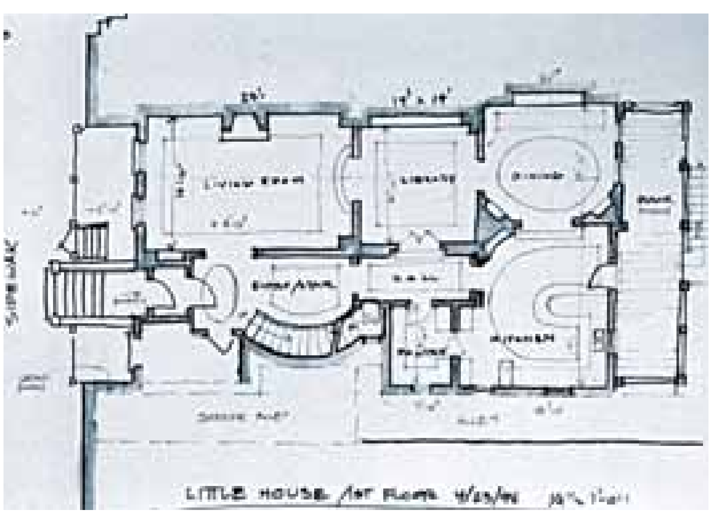
Pre-visualization is a tool to be used for both expanding creativity, and increasing efficiency, by being a low-cost method of experimenting with the elements of a scene and sequence. It allows the director to plan ahead, and to avoid problems that cannot be predicted.



Effects Work on Stuart Little

There were three different categories of effects work done on Stuart Little, all designed and executed by Rob Bredow.

The types of elements created were for water effects, bed and cloth depressions, and particle effects. All of these effects were done with the goal of integrating Stuart in with his environment to enhance the realism of the shot. While they were not the primary focus of the shot, they helped Stuart react with his surroundings in a convincing way.



Water Effects

There was some large-scale water work done for the extension of the Central Park lake in the boat race sequence. We were required to extend the lake that was shot on set in some cases to make it appear larger.

To do this, the matchmoved surface of the water was rendered as a flat plane enhanced with a Renderman shader. Colors were matched to the existing water in the plate, and a displacement shader was used to ripple the surface in a pattern similar to the lake. To get realistic reflections of the lakeshore background, the plate was mapped onto a card that was used in a raytrace reflection pass.

Most of the small scale water done was dependent on a single refractive prman shader that was modified depending on whether it was used as splashing water, a teardrop, a soap bubble, or shallow water in the washing machine.

The water shader would have a specular pass and a geometric normal render pass. The normal pass was used in conjunction with an image processing utility that would warp or refract the background plane using the normal pass to determine which pixels to displace. This refracted piece was combined with the specular pass in the composite for a water look.

To create splashes, Houdini's particle system was used to generate the motion, then spheres were instanced to the particles. These spheres were displaced based on their velocity, and also distorted in world-space in the Renderman render to shake like water. This added a subtle specular change that gave more life to the particles.

The teardrop that we had to create on Stuart's fur was hand-animated in Maya, and then the water shader was applied. Additional trail elements were generated out of this animation that were passed to our fur for clumping, and to the composite for dialing in wet components like specularity and brightness.

The soap bubble that Stuart spat up in the washing machine used a variation of the water shader. It did not include the geometric normal pass used for refraction, since we decided that the soap bubble's surface was too thin to do much refracting. It did include the specular pass, and an environment pass and rainbow pattern pass that were all balanced in the composite.

Our last water effect was the surface of the water in the washing machine that Stuart was partially submerged in. In this case, Houdini was used to create a modulated surface that refraction and reflections were added to. This was a trickier refraction effect, because it had to be very close to the refraction showing in the plate.

To do the water surface refraction calculation, Rob Bredow came up with a Renderman shader that would use the matchmoved geometry, and raytrace to find the correct amount of distortion based on water's index of refracion and the distance of the objects from the camera. This was calculated as an amount of pixels to be distorted in screen space, which was passed to our image warping utilites.

We started out trying the real index of water at 20 degrees Celsius, but ended up cheating it based on what looked good.

The interesting thing was that when we ended up with our final preferred refraction, Stuart's image warped shoes lined up with the real distorted ledge in the plate that Stuart was standing on.

Bed Depressions

Whenever Stuart was standing on a soft surface, like a bed, or a piece of cloth that he was climbing, or on a sail that he was sliding down, we tried to make the surface deform with his weight. The intent was to make it look like Stuart was affecting his surroundings This effect had two components: deformation of the surface, and lighting changes.

The deformation of the surface was done with a variety of methods, each depending on the animation of Stuart, the camera view, and the complexity of the shot. It could be done with metaball animation in Maya or Houdini, or by using projected texturemaps and displacement shaders. The important part of this aspect of the depression was to get a convincing animation that would react to Stuarts contact points, and then bounce back at a rate that looked right for the fabric.

The lighting changes that were caused by the indents were calculated by taking into account the lighting differences between the undeformed and deformed geometry. A light calculation was done on the undeformed surface geometry (using a Renderman P-Ref object typically for the original surface) and then also done on the new final deformed surface. The difference between these lighting calculations was used to modify a projected texture taken from the original background plate.

Particle Work

Because of Stuart's small scale, many of his interactions with his environment were done with very small elements that lent themselves well to particle work. Some of these elements included pebbles, goldfish crackers, and dust.

Most of the particle work was done in Houdini using the POPs operators, which gave us a lot of flexibility in terms of controls and attributes that can be passed through to Renderman.

Typically, an animated Stuart geometry was exported from Maya, and imported into Houdini. Pieces were used from this animated model to act as collision objects with the particles. Magnets were also in some cases attached to objects like Stuart's feet, to drive the animation procedurally.

To animate pebbles, the particle system would be set up to generate lots of pebbles procedurally, and then specific pebbles were chosen to be removed or modified from the simulation. There were always special considerations on how the pebbles would come to a stop at the end of their animation, and special expressions were used to cause them to bounce and roll realisticly. They were then rendered with motion blur using their velocity vector in Renderman.

For dust, a Houdini particle system was used, and then texturemapped spheres were instanced to the particles. To animate our goldfish crackers, it ended up being easier and more controllable to hand animate them in Maya. At other times, as in the case of peanut crumbs, it was more efficient to use the particle system. The choice was most often made based on the size of the objects, the number of them, and the amount of control needed in their collisions and rotations.

For our leaf animations, some were done by hand (larger leaves) and some were done with the Houdini particle system (smaller ones). The leaves were taken from the plate by modelling based on a trace of the image, then rendered using the same deformation shader used in our bed displacements. This allowed the leaves to used the projected texture from the plate and also respond to lighting changes as they animated in the scene.

Compositing Tools

Aside from traditional compositing techniques used, Stuart Little demanded special attention to certain compositing integration techniques. The main purpose of our compositing was to help Stuart fit into the plate, and our compositing tools and techniques were tailored for this purpose.

Composer 5.0 was the primary compositing package used on the show, although Stuart Little was also used as a testbed and benchmark platform for Imagework's in-house compositing system in development. However, most of the compositing issues that we dealt with were generic problems, independent of the software used.

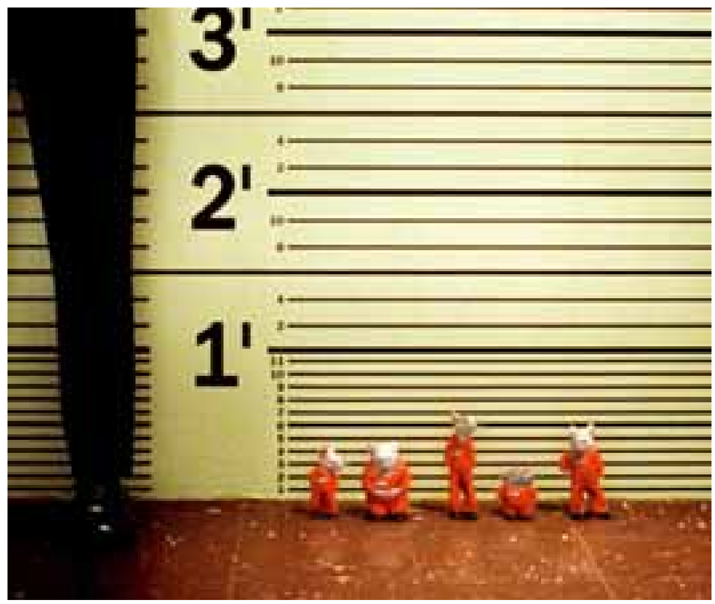
Because of the extremely shallow depth of field required in shooting a small mouse-like object close to screen, we had to deal with a lot of depth of field issues. Artists would render additional z-depth passes with their CG elements, then use our in-house Composer plugin ZSpread. This would apply a defocusing filtering algorithm to the CG elements based on our z-depth pass. It could dial in the amount of spread and also modify the area of its falloff. We would often keep the front or head of Stuart in focus, while softening the back of his ears or tail.

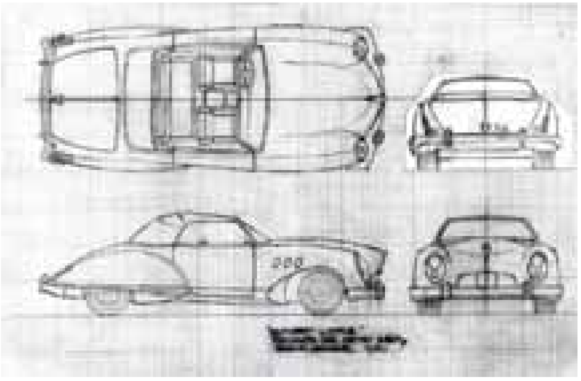
In many of the plates, the area that Stuart was placed in was out of focus. In this case, we would apply what we affectionately referred to as "height of field" (HOF) to Stuart. We would keep his face in focus, and apply a vertical gradient to soften different parts of his body that were in proximity to the defocused plate.

We came up with some different plugins to apply 2D corrections to our CG elements, mostly because we did not want to always have to re-render CG elements with long render times.

Two of these tools were our RotoShadowFix and RotoHighlightFix. These were Composer macros that would accept a garbage matte to isolate an area, then key in the area and lift shadows or reduce hilights. This proved valuable for lifting dark spots in Stuart's fur or brightening objectionable shadow accumulations.

Another tool was written was a CG cloth dustbusting macro, for a period when our rendered cloth had





sparkly artifacts. This was quickly solved, but in the meantime this compositing tool allowed us to automatically key out these hits and replace them with a cloned color.

Also, a lot of attention was paid to the application of film grain to our CG elements. Initially, grain from our film stock was analyzed by comparing an image averaged plate to a running locked off sequence. A default level was setup in a Composer macro, with red, green, and blue amounts dialed in separately.

Here's some statistics about which types of the more traditional compositing operations were most often used in our composites:

In	**avg= 21 max= 71**
FileIn	**avg= 17 max= 67**
QBlur_Sp (blur operation)	**avg= 10 max= 45**
Over	**avg= 9 max= 42**
TravelMatte (garbage mattes)	**avg= 9 max= 29**
Out	**avg= 5 max= 25**
Fade	**avg= 5 max= 65**
Brightness	**avg= 4 max= 39**
Move2D	**avg= 4 max= 28**
Switcher_Sp (channel switcher)	**avg= 3 max= 29**
PrimaryCC (color corrector)	**avg= 2 max= 29**
MMult_Sp (premult/unpremult)	**avg= 2 max= 31**
Arithmetic	**avg= 2 max= 26**
Grain_Sp	**avg= 2 max= 7**
MultRGBM_Sp	**avg= 2 max= 40**
Add	**avg= 2 max= 15**
LinearLumaKey	**avg= 2 max= 14**
Gamma	**avg= 2 max= 21**
Blur	**avg= 1 max= 23**

In all, we used 120 different operators, depending on the types of things we were doing in the composite, from greenscreen pulls to image warping.

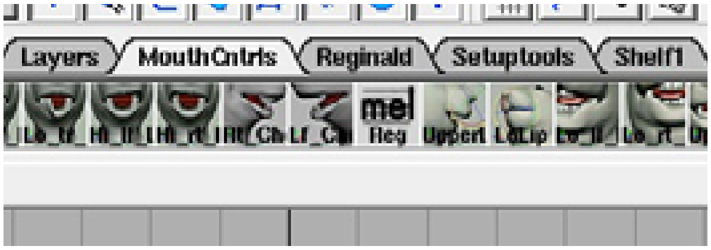
Other Integration Techniques

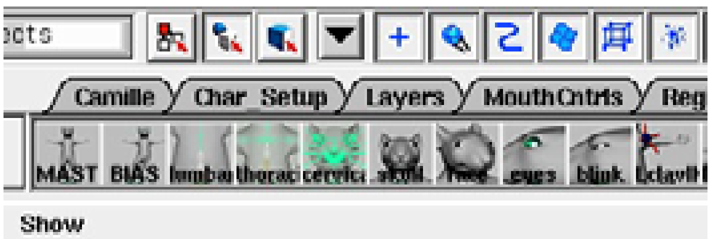
Quite a lot of attention was paid to shadows cast by Stuart onto his surroundings. There were soft shadow techniques designed by Alan Davidson and Rob Bredow in addition to a contact shadow setup designed by Jim Berney.

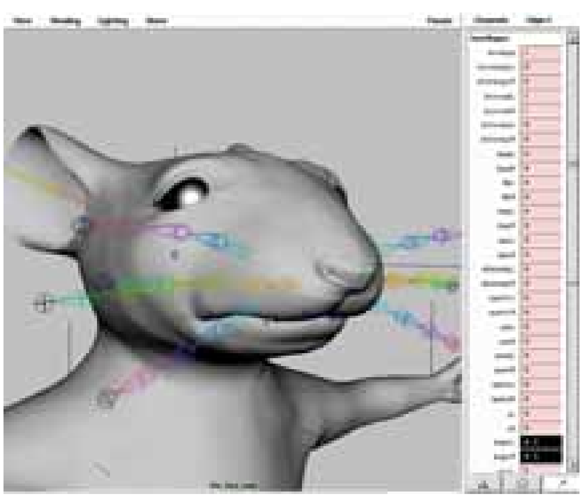
We found it beneficial to place a contact shadow under Stuart's feet and tail when he was standing on surfaces. This would be a very close dark shadow directly under the contact point, that would represent the blocking of ambient light, and a loss of light energy in these tight areas. This was achieved by using z-depth information from a special render pass to produce mattes that were based on the proximity of Stuart to a surface. These were used in our composites to darken the plate under Stuart's feet. They would lighten subtly as Stuart's contact points separated from the surface. This helped give the impression that Stuart was standing on the surface and making real contact with it. It blended with cast shadows to give a multi-dimensional look to our shadows.

We also worked on giving a falloff in density and sharpness of Stuart's cast shadows. If we could do this in the composite with a gradient we would, but otherwise we used a series of special procedurally rendered mattes to soften the shadows based on their distance from the surface that was blocking the light.

Physiquing and Character Setup







Physiquing refers to the setup of a character. This includes the making of IK handles, the skeleton, and the binding of that skeleton to the skin model, allowing the skin to move smoothly with the skeleton.

It also involves the setting up of controls to animate the character. John McLaughlin and Todd Pilger were artists who were instrumental in setting up the pipeline and tools for the characters on Stuart Little. Evan Smyth and Bruce Navsky from the software department also added to our group of tools and Maya plugins.

The physiquing started when we got the first Stuart model. Our model went through many changes and ended up being a semi-anthropomorphic character. Stuart was upright much more than a real mouse, and had a somewhat human type body, yet retained mouse-like characteristics. Kevin Hudson and the modeling department created a lot of detailed pieces, from toes on Stuart's feet (that were never seen because he always wore shoes) to teeth modeled after Imageworks' own Barry Weiss.

Special physical characteristics made Stuart different from a real mouse. Stuart's neck was very wide, his hips were large, and he had very closely spaced legs that were short. The arms of Stuart were short, which made it difficult for him to reach around to his back and across his chest. Scaling controls had to be added to Stuart's arms to be able to do all the animation required of him. Stuart also had difficulty being put into a sitting position, since it was so different than his default modeled position.

The neck in particular was a very problematic area to physique in the model because there was a lot fur in that area, and it had a large range of motion. Bends, folds, and cracks would get translated over to the fur and would cause it to flip around.

It also was a problem because the neck had to look natural and could really not crease, because it had to tuck nicely into the cloth. One problem we had was at the border of a neck patch. It was in a very inappropriate place right above the collar line of Stuart. We found out that any differences in the normals between the patch above and the patch below would cause a color and lighting difference between the fur and neck.

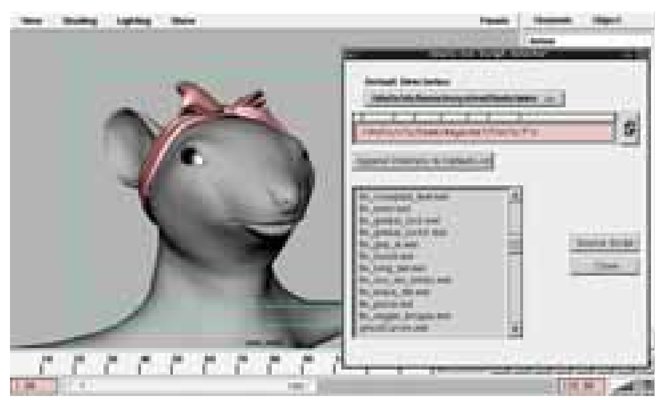
Because Stuart's body was used as a collision object for the cloth it was important that adjacent surfaces never came too close together, like in the underarm area. Additional deformers were added to these areas to prevent problems for the cloth simulation. This ended up creating a distorted looking body under the clothes, but since this surface was never seen (only Stuart's head, tail, legs and hands were seen naked) it ended up being fine.

Animation Support

Character setup and animation support involves the front end of the pipeline, which includes a handoff from the matchmover, incorporating the matchmove camera and object into a Maya scenefile that the animators can start working with.This initial file would be checked by the animation director, Henry Anderson, before it was handed off to the animator.

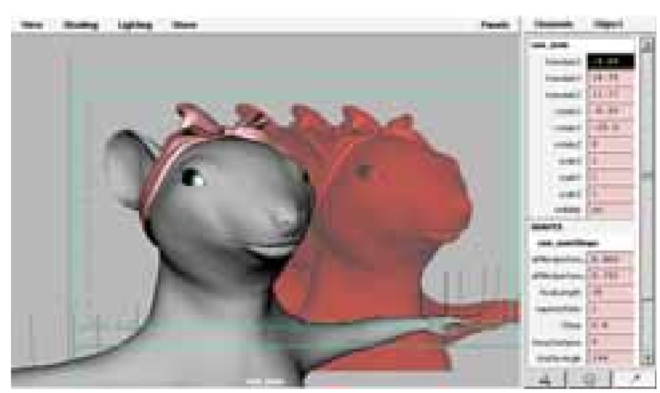
This file had to include the character, placed in a scene that is roughly in the correct spot and scaled to the appropriate size. Anthony Serenil and Peter Nofz wrote many Maya MEL scripts to handle these tasks automatically.

As the animators animated and ran into problems, the TD support team helped them work out their issues. If animators needed help upgrading their model, (depending on if changes were made), the support person would do it. They would also help animators by custom rigging their model and by making sure that the props were all correctly constrained and set up. Once the animator would finish with a shot, they would make sure it was placed in the shotree correctly, and use Peter Nofz' designed tools to check in animation files (similar to the matchmove check-in tool).



Tools that were written to make our lives easier:

- One Button tool for swapping out matchmove info and geometry.
- One Button tool for swapping in/out background plates.
- One Button tool for swapping out audio.
- Tools to reduce complexity of characters in Maya scenefile.
- Easy to use publishing and versioning tools with e-mail notification.



Props

Aside from the set pieces modeled for matchmoving, Alex Whang also created 3D models that were used interactively by Stuart. We found that it was easier to create a 3D model for the animator to animate it, and the lighter to texture and render it, than it was to use a practically animated real set piece.

These are some of the props that we ended up creating for the film:

remote control
toothbrush
comb
miniature book
camille's purse
suitcase
ladder
boat wheel
very tasty nuts
roadster steering wheel
roadster body used in reflections

Each of these got a texture painted by John McGee, and were lit and composited into the scene with Stuart.

Faceshapes

Faceshapes were created under the supervision of animation director Henry Anderson, and the modeling department, led by Kevin Hudson.

There were somewhere between 60 and 70 faceshapes created, depending on who you ask, and all were subjected to scrutiny by the lead animators Eric Armstrong, Anthony La Molinara, and John Clark Matthews.

These faceshapes were setup as blendshapes in Maya, and quickly ended up slowing down interactive speed, and making files larger and larger. To help alleviate this, John McLaughlin helped develop on-demand loading tools on the front end, and Mark Hall developed faceshape pruning tools on the back end to reduce file sizes.

This is a list of some of our most popular face-shapes, in order of use (gathered by Mark Hall):

browsurpR (suprised brow)
browsurpL
browsadR (sad brow)
browsadL
sadR
sadL
openoR (open "o" shape)
openoL
skeptR (skeptical)
skeptL
squintL
squintR
smileR
smileL
llsadL (sad lower lip)
llsadR
toothygrinR
toothygrinL
browangryR
browangryL
snarlL
scrunchedL
scrunchedR
snarlR

Challenging Animation Setup problems during production:

1) **Integrating NT-Platform into the pipeline**
   Solution: Encapsulate all of our code as much as possible. Try to make everything work the same on both platforms.
2) **Scale of Stuart could not be changed without serious fur & cloth consequences**
   Solution: Scale the world (matchmove plus camera), not the character.
   New Problem: Shots with more than one character, whose scale had to be adjusted individually.
   *New Solutio*n: Break out each character into their own scenefile
3) **Updating different iterations of the character, taking into account per shot customizations, like constraints, ik-handle changes, etc.**
   Solution: lots and lots of code, versioning info.
4) **Updating different model iterations of props and accessories**
   Solution: lots and lots of code, versioning info.
5) **Keep tracking of versions in every animator's file**
   Solution: Versioning nodes, programs that gathered statistics and e-mail.

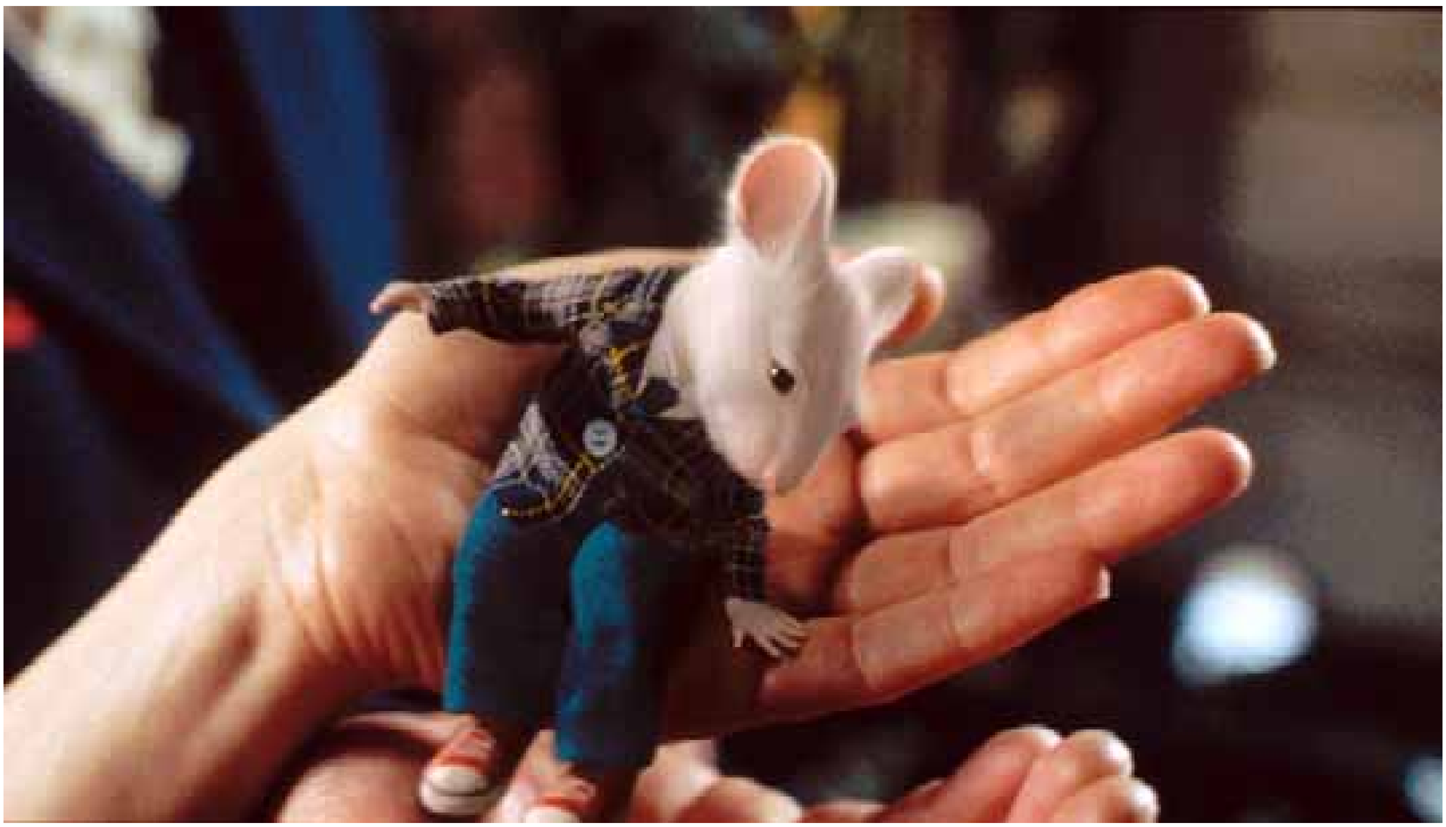
Acknowledgments

Jay K. Redd, Jim Berney, Peter Nofz, Andrew Titcomb, Rachel Nicoll, Rob Bredow, Danielle Davis, Sande Scoredos









Course #14, SIGGRAPH 2000
New Orleans, LA, USA

Stuart Little: A Tale of Fur, Costumes, Performance, and Integration: *Breathing Real Life Into a Digital Character*

Character Animation

Henry F. Anderson III
Sony Pictures Imageworks, Culver City, CA

Animating Characters on Stuart Little

One morning when the wind was from the west, Stuart put on his sailor suit and his sailor hat, took his spyglass down from the shelf, and set out for a walk, full of the joy of life and the fear of dogs. – *Stuart Little, chapter VI*

I loved E.B. White's book Stuart Little when I was a child. Stuart's adventures in New York City, and his subsequent adventures as he drove north following his heart, were part of my childhood memories. Stuart's heroic exploits in the boat race, his friendship with Margalo, and his journey in his little car were all easily recalled.

Therefore, it was with fondness that I returned to the text when I was first approached about working on a film adaptation of the book.

The paragraph quoted above, taken from the chapter that includes the boat race, is so descriptive, so communicative, and so evocative, that the reader instantly has a sense of the scene, the character, and the tone of the story. And, all this is accomplished in one long sentence.

When Columbia Pictures undertook to adapt Stuart Little to the screen, they were immediately faced with one of the challenges that filmmakers have long faced. Namely, taking a character that has existed (and in fact grown beloved) in book form and translating that character into the visual world of the cinema. The world of the written word and the world of film couldn't be more different in the way in which they communicate a character's thoughts to an audience. When one reads a book like Stuart Little, the reader is told what Stuart is thinking... whilst in a film, particularly an animated film, the audience must be shown.

Since it was clear from the start that Stuart would be the film's leading man (or mouse), the work of the animation team became essential to communicating the character's thoughts and emotions. The animation team was responsible for Stuart's acting, and therefore was responsible for communicating as much of Stuart's 'inner life' as they could through his actions.

He was an adventurous little fellow and loved the feel of the breeze in his face and the cry of the gulls overhead and the heave of the great swell under him.
– Stuart Little, chapter VI

Just like any other actor in a live action film that is preparing for their role, in order to understand Stuart as a character it was important for the animators to understand his motivation. What makes Stuart think like Stuart? To answer this question it was important that he have a back-story... a history that would allow the animation team to understand Stuart as an individual and to imagine how he would respond to the incidents in the script.

By taking elements of the Stuart character from the wonderful world that E.B. White had created in the original book, and trying to blend these with the script that had been developed by the studio, we came up with a very good understanding of who Stuart was to us. He would still be responding to the situations in the script, but he would have a depth to his character that would go beyond the dialogue that he was being given, and which would motivate his movements from the tip of his nose to the fidgeting of his fingers.

When Mrs. Frederick C. Little's second son arrived, everybody noticed that he was not much bigger than a mouse. The truth was, the baby looked very much like a mouse in every way.
– *Stuart Little, chapter VI*

At the same time that we were trying to get to know Stuart as a character, we were working on his design. Obviously, it was important that Stuart be an appealing character and that his design be flexible enough for him to be a communicative actor. But we also knew that he would have to look "very much like a mouse in every way."

One of the most important elements of Stuart's design would be his face.

It would need to be very expressive and communicative in a human way, while still maintaining the feeling of mousiness. And, since we had decided to use solid black eyes, with no whites at the edges, the shape of his eyes would be critical in determining his attitude and even which direction he was looking.

We explored a wide broad range of Stuart designs in order to find a balance between a mouse and a young boy, which is how we always thought of Stuart.

Some of the designs tended toward being more like a real mouse, while others inclined toward being more human.

In the end, we came up with a design that everyone agreed was "cuteness" (whatever that means) and expressive. But, more importantly we had a design that looked like Stuart to us. The Stuart that we were getting to know.

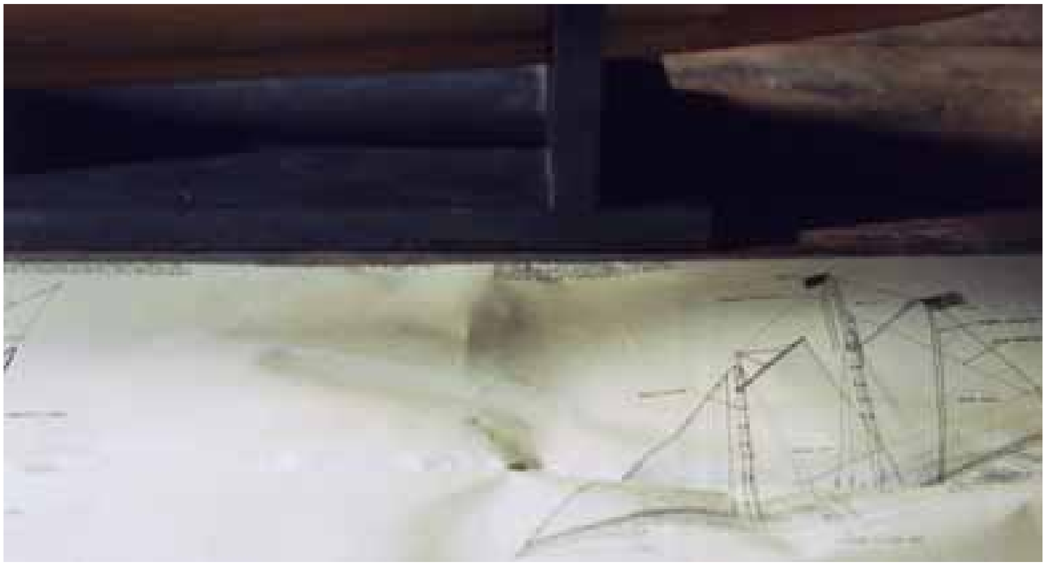
Even when we'd see him in a still image, we wanted Stuart's pose and attitude to convey his personality. After all, we were animating with 'keyframes'... and those key poses should be able to tell much of the story by themselves. They would give the viewer a sense of who Stuart was, and what he had on his mind, even before he started to move.

He was only about two inches high; and he had a mouse's sharp nose, a mouse's tail, a mouse's whiskers, and the pleasant, shy manner of a mouse.
– Stuart Little, chapter I

In addition to Stuart's inner motivation, which was the key element in defining how he would move, we also had to keep in mind that our leading man was very small and would need to animate in a way that would be consistent with how he moved in the real world. Small character would be effected by real world physics. We treated Stuart like he was made up of flesh and blood, like the other actors in the film.

To keep this feeling of realism, we tried to avoid excessive squash and stretch and to keep Stuart's biomechanics in the real world at all times. He moves like he has a skeletal structure, without a 'rubber hose' feeling. And, since he is so small, his ears never flop when he runs. They only move when the muscles underneath motivate them.

Our goal throughout was for the audience to accept Stuart as a believable leading character. This could only be achieved by knowing our character thoroughly, and creating a performance that was as unique as the character that we were portraying.



Course #14, SIGGRAPH 2000
New Orleans, LA, USA

Stuart Little: A Tale of Fur, Costumes, Performance, and Integration: *Breathing Real Life Into a Digital Character*

Bringing It All Together: *The Screen Test*

Jerome Chen
Sony Pictures Imageworks, Culver City, CA

Stuart's 'Screen Test'

The purpose of Stuart's "screen test" was twofold: to provide Sony Pictures studio with an indication of our ability to do the work for the film, and to also create a clear point of focus for all the efforts of the research and development phase.

We designed a test that represented, as best as we could predict, the scope of all required technologies and techniques necessary to accomplish the show. It was prudent to create a testbed where we could plug in any developing technology and evaluate its state in a consistent environment.

The screen test was a 30-second shot depicting Stuart Little grooming himself in front of a mirror. The shot begins with a close-up of Stuart's reflection, and pulls back after the mirror is inexplicably fogged. Stuart throws an irritating look off-camera, and the frame pulls back to reveal his full figure (and reflection) plus Snowbell the cat. Dialog is present throughout the shot.

This was a complicated test. It entailed almost every aspect of what we anticipated to be necessary for a 'typical' Stuart shot: a seamless integration of a furred and clothed CG character with a live-action plate. The following processes were necessary to complete the shot.

1. Photography

The screen test was a 'safe' testing ground to help us plan how we would deal with problems once we began main photography. Live action photography is very expensive, and there is considerable pressure on the visual effect crew on set to ensure that the proper techniques are followed to capture the background plate. To avoid delaying the crew, it's essential that we show up with contingencies for all possible problems arising on set. The captured film image defined the creative parameters on how we would integrate Stuart into the scene. Where was the light coming from? Where does the focus fall off? These types of questions prompted us to consider what type of digital compositing and 3D lighting tools were required to help the artist accomplish the final shot.

2. Input

This involves scanning original negative on a specialized scanner, digitizing the image into 2048x1556 resolution 10-bit log raster images. The screen test would help answer whether the resolution and bit-depth satisfied the quality level we desired for the film. It would also help benchmark throughput parameters in terms of processing times and disk space use for these types of file sizes.

3. Camera matchmove

Recreating in 3D the motion of the real camera which captured the plate is a vital step to insure that Stuart's perspective matched the film image once he was rendered and composited. Matching the camera includes a simulation of certain characteristics of the real lens in the 3D-rendering camera.

4. Character setup and animation

This process involves the creation of the animation controls necessary for an animator to give Stuart his performance. Skeleton creation, limits for joint rotations, facial controls - every aspect of creating a digital puppet required testing and refinement. The screen test was the perfect test bed to reveal weaknesses in our design. Again, Maya was the backbone of our production pipeline; custom plug-ins were written by our in-house developers and supervisors to help streamline the animator's iteration cycle.

5. Cloth simulation

Computer graphics have always had difficulty in efficiently creating realistic cloth movement on a synthetic character. The key to this process is 'efficiency'. Our character was present in several hundred shots; it was required that we devise a fast, multi-iterative pipeline to simulate Stuart's clothes. We were gambling on the Maya cloth plug-in to solve our need. The animation in the screen test was a good indication of whether the plug-in would create the look of realism we sought in a timely cycle.

6. Fur lighting

Our second most daunting technological hurdle was creating Stuart's fur. This involved more than the somewhat mechanical process of populating his head with individual strands of fur; the more difficult challenge was the task of lighting the fur in a manner that both integrated him and also defined his presence as the star of the film. The screen test sought to help us devise the techniques and tools necessary to achieve Stuart's movie star lighting.

7. Digital compositing

This step is a stable process of traditional digital visual effects work. The backbone of our compositing pipeline was based on Alias-Wavefront Composer, and through the years we have built dozens of plug-ins to enhance it's usability and efficiency.

The screen test served to help evaluate the type of new tools to develop and the basic layering strategy of how to break Stuart apart during his compositing stage. Most of this determination was accomplished simply by examining what kinds of creative comments were directed towards the screen test. Comments which caused multiple re-lighting and re-rendering for Stuart's specific components (his head, cloths, hands, etc.) usually dictated what layers required separation. Rendering Stuart separately in specific layers reduced processing time and allowed more specific balancing in the composite.

8. Film output

The screen test offered an opportunity to output digital frames to a variety of film recorders. Different devices offer varying levels of quality in terms of perceived image sharpness, contrast and color saturation. We sent out identical files to both CRT and laser film recorders to create a comprehensive side-by-side comparison of performance. We found that the laser recorder was the most flattering method to bring Stuart to the screen.

The research and development phase is inevitably more successful when it has a focused and obvious purpose. The screen test provided such a focus, in terms of the development effort and allowing the studio and management to monitor our progress in realizing Stuart. It is ironic, however, that we never officially finished the screen test. We abandoned the test when formal production began on the film, opting to take the plunge and throw our efforts onto the real thing.

Results of Stuart's Screen Test. This image shows how far the character advanced by the time of production. Note the overall lack of detail and "cuteness"...


Stuart's Car

Course #14, SIGGRAPH 2000
New Orleans, LA, USA

Stuart Little: A Tale of Fur, Costumes,
Performance, and Integration:
Breathing Real Life
Into a Digital Character

In the Heart of the Production & A Day In the Life *on* Stuart Little

Jerome Chen
Sony Pictures Imageworks, Culver City, CA

Planning the Job

We began evaluating the creative and technical issues for this project in a simple manner: we made lists.

The list included hundreds of items, a combination of questions and tasks. But before we started to design and implement the technology for attaining our creative goals, it was necessary to lay down the foundation for our production machine. The project management team was the core of the production machine that would accomplish Stuart Little. The design of this team was as important as the cloth engine or the proprietary fur technology; in many ways how this team was created was more important. The individuals in this unit drove the momentum of the production and set the level of quality by which the work was judged. Our core team consisted of the following individuals:

1 Senior Visual Effects Producer (Michelle Murdocca)
1 Executive Producer (Debbie Denise)
1 Digital Producer (Lydia Bottegoni)
1 Animation Producer (Audrea Topps-Harjo)
1 Digital Production Manager (Jody Echegary)
1 Vendor Producer (Jacquie Barnbrook)
1 Marketing Producer (John Clinton)
1 Digital Coordinators (Amy Adams)
2 Production Coordinators (Mickey Levy/Cyndi Ochs)
1 Senior Visual Effects Sprvsr (John Dykstra)
1 Visual Effects Supervisor (Jerome Chen)
1 Animation Supervisor (Henry F. Anderson III)
4 Computer Graphics Sprvsrs (CG Gods)
(Jim Berney/Bart Giovanetti/Jay Redd/Scott Stokdyk)

This is a large group of people who have to essentially function as a single unit, but this team was extremely effective because individual responsibilities were clearly defined and performance was reinforced through a reward and punishment system.

People were beaten mercilessly until their duties were understood. We found this to be very effective.

Pre-production: Assigning Teams

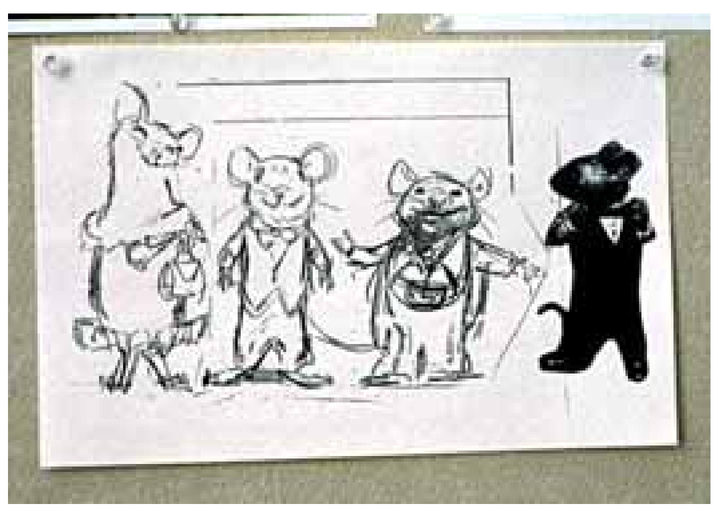
The pre-production phase on Stuart Little had somewhat of a schizophrenic overtone. It was exhilarating, frustrating and terrifying. This was due to the fact that the script was constantly changing and principal photography was months away.

We were forced to guess and second-guess at the nature of Stuart's adventures, and, most importantly, how much development time was available to create the technology for accomplishing any specific effect.

For instance, certain versions of the script depicted Stuart being smeared by glue. This posed a series of technical challenges: fur clumped together by glue, the look of glued fur, the fluidity of the glue itself, etc. Visual artists will tend to fixate on the details, and we knew from experience that details – the ones that add quality to a visual effects shot – require time to create.

It became important to tackle the list of action items we had created. The items on the list were categorized into three levels of priority and then grouped into departments that were led by a CG Supervisor. It became the supervisor's responsibility to assign the appropriate personnel to each task and to schedule and drive that task to either the successful completion of the task or the termination of the person assigned to that task. The supervisor was then responsible for either locating a replacement for that person or completing the task himself.

Here is a short summary of our various departments, their respective leads and a few of their actual responsibilities:



Fur Creation and Color/Lighting (Jay Redd)

This department designed and implemented CG lighting tools and procedures for the artist to light Stuart's fur, his clothes, plus all the ancillary CG elements necessary to fully integrate Stuart into the live action such as reflections, shadows, etc. This was an extremely complex pipeline in terms of the amount of controls necessary to effect Stuart's lighting and surface attributes. An artist could control Stuart down to an absurdly minute level of detail. The opacity of his whiskers, the amount of moisture on his nose, the level of bump on his nose, the brightness and size of the highlight on the meniscus along his eye, the size and position of an eye-light - these were among literally hundreds of controls available. The CG Supervisor, as the head of this department, was responsible for recording the successful techniques used by the artists and insuring the dispersal of this knowledge to the other artists either by classroom methods or through on-line documentation. It was also necessary for the supervisor to address technical problems with the pipeline and optimize the lighting process to allow as much iteration as possible.

Jay and a team of developers spent six months creating the technology for Stuart's fur and initial design of the character. Most of the team is still in drug rehabilitation for amphetamine addiction.

Surface Shader/materials and Cloth (Jim Berney)

While the lighting department devised methodologies, this department was responsible for creating the actual Renderman surface shaders that provided the look and texture for all of Stuart's costumes, plus the various necessary props.

The group also created the process for creating Stuart's digital clothes – quite a daunting task and certainly an area where much of the success of the show rested. We would have failed in one of our creative goals if the cloth, like the fur, failed to convince the audience of Stuart's realism. In assuming the role for department head, Jim Berney placed his career at risk.

Obviously Jim's team was successful; the digital cloth was considered a triumph.

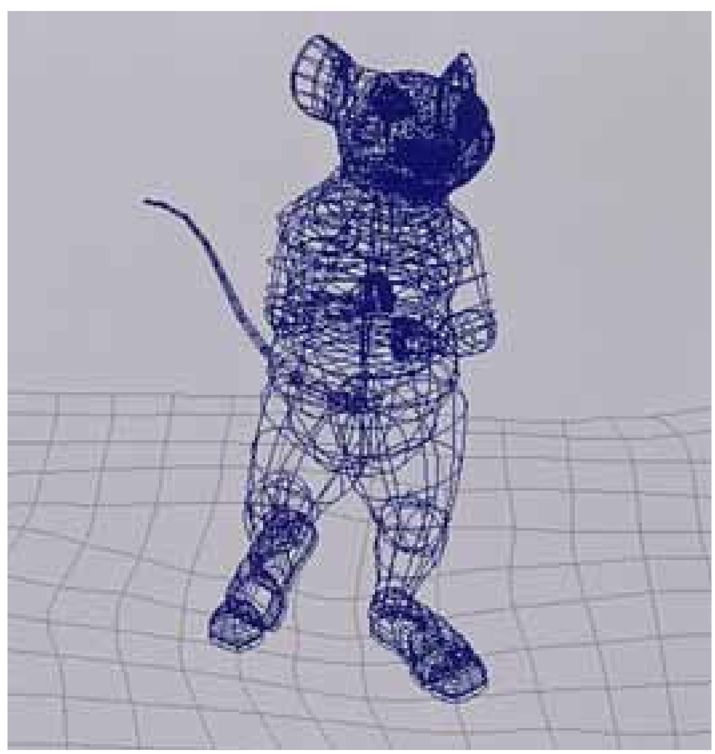
Upon completing the film Jim Berney resigned from the company and is now a multi-millionaire founder of an Internet start-up. Nah, he's still with us.

Character set-up, EFX Animation, and 2D Compositing (Scott Stokdyk)

Once Stuart's design was approved in terms of his proportions and countenance, a team of specialized animators and software developers set about preparing his body and face for character animation. The character set-up process involves creating a digital skeleton for Stuart and designing a software interface for animators to control his various components for performance creation. This is a difficult process to schedule because problems with animation can occur throughout the course of the production.

Performances are impossible to predict during the set-up period, and particular actions can reveal bugs in Stuart's set-up. An error usually takes the form of an abnormal bulge or odd deformation when Stuart would turn his neck or lift his shoulder in an extreme angle.

This department was responsible for maintenance on Stuart throughout the production. Scott's group also developed technology for creating required elements for Stuart's physical interaction with his environment. Stuart's visible effect on his environment helped heighten his realism, so we leveraged any opportunity to use it. For instance, Stuart walking across a bedspread would cause deflections in the cloth, or his feet shuffling across a gravel-strewn sidewalk would cause some pebbles to stir. During the pre-production period, based on reading the script, Scott would delegate certain development tasks to his crew with creative direction from the visual effects supervisors.



Transitioning into Production

Official production began when approved cut sequences were delivered to Imageworks. Delivery took the form of an Avid media file, sent by production editorial, along with count sheets stating which pieces of original negative required scanning.

Meanwhile, more digital artists and animators were crewed onto the production. The production management team now had three times the amount of personnel to oversee, so the organization and responsibilities altered to accommodate this growth.

The lead creative figures, the visual effects supervisors, were dispatched to stage to work with the first and second unit teams. CG Supervisors were then assigned specific sequences from the film to lead, along with artists and other digital support personnel. The various pre-production departments were now active in production, and the CG Supervisors were still responsible for maintaining them.

During this period the producers were heavily involved in both short-term and long-term planning for completing the project. Short-term planning dealt with daily and weekly goals in terms of allocating artist and computer resources for completing shot work. Long term goals entailed the overall deadline for the show and shifting resources to reach that goal based upon the results of the short term goals. Obviously the long-term goals were directly dependent on the consistent success of the short-term goals.

A team of producers focused on specific areas of the project. Lydia Bottegoni and Jody Echegary worked closely with the CG Supervisors in the Imageworks digital production effort; they struck a high level of collaboration and communication to constantly shift and adjust a fixed level of manpower and resources to accomplish the job. Debbie Denise was also involved in focusing the digital efforts and aiding the internal accounting of the project. Animation production, crucial to the pipeline because it was at the front-end of the work, was managed by Audrea Topps.

Visual effects material for the extensive Stuart Little marketing effort was produced by John Clinton, and CG supervised by Bart Giovanetti. The efforts of Centropolis Effects and Rhythm and Hues Studios in creating the talking cats was coordinated by Jacquie Barnbrook, with assistance from Cyndi Ochs.

As the digital production crew became entrenched in the business of producing shots, high-level managers began working with the studio executives at Sony Pictures Entertainment on budgetary and scheduling issues. The senior visual effects producer, Michelle Murdocca, functioned as the primary liaison between Imageworks and the studio, providing weekly reports on Imageworks' production status. It was her job to also breakdown and bid the storyboards with the CG Supervisors, which created a budget requiring continual revision and updating.

The collaboration of these individuals resulted in the extremely successful delivery of the show in terms of budget and quality. The work in Stuart Little encompassed almost 650 visual effects shots, created by almost three hundred artists from three facilities and several matte painting studios.

A Day in the Life *on* Stuart Little

as seen by Jerome Chen – Visual Effects Supervisor

9:08 am — Dailies

I arrive late for film and video dailies in the Corner Theater at Imageworks. The room is huge, enough for two hundred people. The entire crew (50+ artists) sits waiting. Josh, the projectionist, turns off the techno music that he's been blasting into the theater in an attempt to keep everyone occupied. We look at shots on the digital projector for almost 90 minutes.

Film outputs from the previous night are late, as usual. We have a meeting with Rob Minkoff (the director) at noon to present him the finals. We see one funny test that shows varying sizes of breasts for Camille Stout, the female mouse who pretends to be Stuart's real mother.

The studio has commented that her breasts were too large; now we're doing size tests.

Even with this lighthearted moment, ninety minutes of dailies gives me a headache by the time we leave the theater. All I think about is that I haven't had breakfast yet.

10:30 am — Touchbase Meeting

The production team (producers, coordinators, CG Sups, Dykstra and myself) meet in John Dykstra's office for a group panic attack. Dailies have revealed that half the shots meant to be finalized for the week appear to be nowhere near completion. We restrategize. Shots in better shape are moved up in priority. The slate of nightly filmouts is determined by the group.

The meeting breaks up when we're told that the film has arrived from the lab. We move like a herd down the hall towards the upstairs screening room.

Jody Echegary (the digital production manager) has a cell phone to his ear, having an animated conversation about system resources with someone.

As we reach the screening room he tells me that it's unlikely that all the filmout goals can be met for that night. The plan we established not even ten minutes ago has unravelled. I ignore him. Dykstra glances at me and asks what the problem is. "Nothing," I tell him.

"Everything is fine."

11:15 am — Film Review
Third floor screening room

This theater is small and plush - the decor is soothing earth tones. The walls are ultrasuede. There are five big leather chairs, quickly taken because almost twenty people pile into the room. Dykstra and I take the chairs straddling the console. We take out our laser pointers and everyone sighs. Including the CG Sups', there are now five laser pointers in a screening room with seven seats.

One always expects the best from the previous day's work but surprises have become the norm. We leave to meet the director in less than half an hour.

We need film to bring with us and this batch is it. Dykstra tells Josh to roll it. The lights come down and the Imageworks head leader appears on the fifteen foot screen.

The first shot comes up. It is Stuart on a table, talking to George. Everything looks good except for the fact that the print is so green that it's impossible to evaluate the quality of the shot. We curse the lab, then debate about whether to bring the shot with us. We decide to look at the rest of film dailies. Most of it looks good, but the entire roll is green.

John and I call for a reprint and continue debating about whether to bring the roll or not. It is only thing we have to show. I can feel the producers squirming in the chairs behind me.

Today is Wednesday, the day of their weekly 'flogging' meeting. This is when Michelle Murdocca and Debbie Denise go and give a weekly status of the project to the studio execs at Sony Pictures. The studio wants Stuart to become a big franchise for them and has a very keen interest in our weekly progress. So far, our progress has been excellent and everyone is very positive, but I always feel like we're hanging on by the skin of our teeth.

I ask if there are any video tests we can bring. Amy Adams (the digital coordinator) reminds me that the breast size test needs to be approved.

"Great, put it on tape." That plus the green film should be enough to keep Rob happy.

I wonder when we're going to have lunch.

12:10 pm — Director Review Thalberg Screening Room D

We're late, but nobody's in the theater. Michelle Murdocca, Amy Adams, Dykstra and myself file into our usual seats (the same seats we've each taken everyday for the last year at this noontime screening).

Fifteen minutes later Rob, Tom Finan (the editor), and Jason Clark (the producer), come in and take their seats behind us. Tom nods curtly to us and Jason is boisterous. Rob is reading Daily Variety, barely acknowledging our presence. Jason asks us what we've got to show. Dykstra and I respond enthusiastically. We decide to first show the breast test. The video tape rolls.

"Whoa!" Jason shouts. "They're huge!"

Rob looks up and starts to laugh.

"We made them smaller," says Michelle.

"She's got, uh, well..." Rob tries to find words.

"Hooters," offers John.

Tom, the editor, says nothing.

"We'll take care of it," I say hastily.

"Let's move on."

We run the film. We go through the roll once to watch all the shots, then go back to the head. Jason laughs at the Stuart's dialog. Rob is still, quiet even after the second viewing. Dykstra and I turn and ask:

"Well?"

Rob stands up. "Everything looks great."

The lights come on and everyone gets up to leave. Dykstra and I look at each other and shrug. "Let's go eat," he says. Thank god, I think.

12:45 pm — Lunch @ the Food Court

I phone in a status report to Lydia Bottegoni, the digital producer. Every day at this time she waits anxiously for the word on what shots have finalled.

The CG Sups are often with her, waiting together in her office for word of their fates. There is a heavenly feeling of lightness when a shot is finalled. One more hash mark on the progress board, one less shot to render, one less shot on the disk server.

After debating with each other about where to eat, Michelle, Amy, Dykstra and I have lunch at one of the same four restaurants we've eaten at for the last year. We can order for each other by now. We eat quickly so we can get back to Imageworks to do walk-throughs with the artists. On the way back we stop at the Conservatory, a coffee shop where we fuel up on double vanilla lattes.

2:00 pm — Artist Walk-Throughs @ Imageworks

My vanilla latte just barely staves off a food coma threatening to lay me out. I wonder if I've become immune to caffeine. I don't want to become one of those people who only gets a jolt from a Starbucks Macchiato, which is four shots of espresso and a splash of foam. Dykstra and I follow Amy Adams through the rabbit-warren of cubicles through the heart of Imageworks, peering at one monitor after another. The CG Sups lead us around like tour guides, trying to extract some hint of creative direction or approval from our half-comatose brains. We review shots in progress.

The artists have heard the same kind of comments for the last year:

"More fill light." "Soften his shadow." "Warm his color up." "He looks too smooth."

For some time now I've wanted to just apply code numbers to these comments.

This way you could tell an artist:

"Just do the standard 4-2-7-10-52. Thanks alot." We could blaze through walk-throughs. Sometimes we're on the floor for hours, desperately trying to hammer something presentable for filmout that night.

We go see the artist working on Camille's breasts. He has gone through another round of versions. They are still too big. Dykstra and the artist discuss relative breast sizes for almost fifteen minutes. Amy pulls me out of the cubicle. She has the enviable job of jotting down every comment made by Dykstra, me, and the CG Sups, during rounds, then re-typing them on her computer and distributing the notes to all the artists. She has the pity of the entire crew. "I need more coffee," she says desperately.

6:40 pm — Evening Touch-Base

After rounds I meet with Jody to strategize.

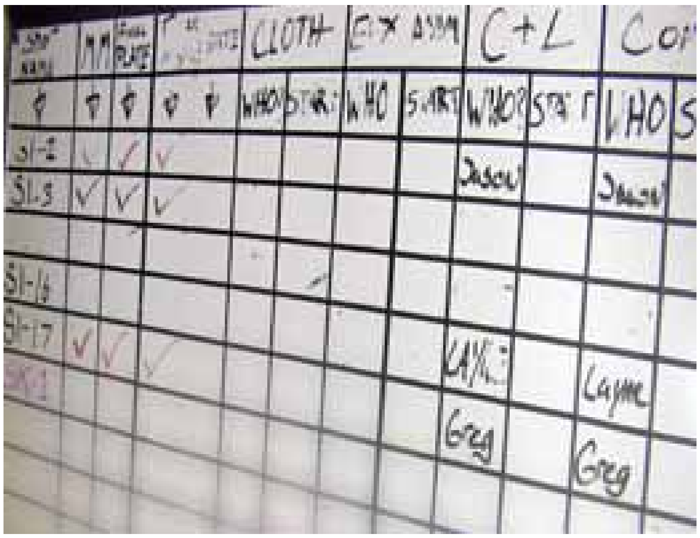
"What do we got?" I ask him.

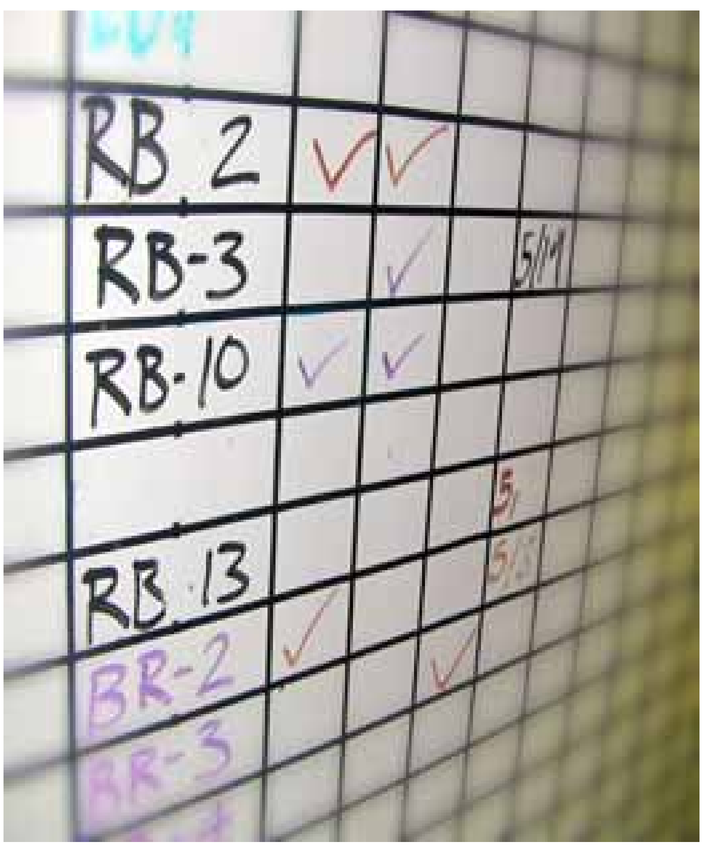
"You know what we got, we got s#!%!" His eyes are wide. Jody runs an analysis every night of our shot completion rate relative to our project deadline. I have a seen a pattern. In the beginning of the week he always tells me that we're screwed; at the end of the week he says we're okay.

Today is Wednesday, so it could go either way. Based upon the walk-throughs we evaluate which shots are in better shape than others. We make up a film-out list.

"Go with God," I tell Jody as he runs off.

coffee^{3} =





7:15 pm — My Office

I sit down at my desk for the first time that day. I check my mail and see 124 messages pending. I try to work my way through the messages but it becomes hard to concentrate.

Partly because I'm tired but mostly from the screaming that is going on outside my office. Mickey and Cyndi, two of our coordinators, argue with each other at a ferocious volume as I begin to pack up my stuff.

I duck past them without bothering to inquire – or put a stop – to their argument. This confrontation, for some reason, has become part of a daily ritual. It does not occur to anyone to try and defuse it. Maybe it is some form of collective venting.

In the elevator I run into Jay Redd, also leaving. We are too tired to talk to each other. The elevator stops at the next floor and the door opens to reveal the three remaining CG Supervisors, Jim Berney, Bart Giovanetti and Scott Stokdyk.

"What, an early night?" I ask. "Or did you all quit?"

"It's called efficiency," says Jim Berney.

"A well-tuned machine," adds Stokdyk.

Almost on cue we all glance at our watches to check the time and date.

"Seven weeks left in the show," reports Bart.

Jay: "One hundred and five shots to do."

Me: "Fifteen shots per week."

The elevator stops at the parking garage. We file out quietly, each heading to their car to head home and sleep. Leaving before 8:00pm hasn't happened for the last few days.

Maybe tomorrow we can get Camille's breasts approved.

Conclusion

The feature film "Stuart Little" was made over the course of almost three years, starting in late 1997. During this time, much in technology was changing, and has continued to change. With rumors of Stuart Little II in the works, a good hard look is being taken at the current set of tools to see how they can be improved upon to allow work to be done better and more efficiently.

While in the middle of production of Stuart Little it was decided that the current set of software had to be "frozen". This set included Version 1.0 of Maya, beta Maya Cloth, RenderMan 3.8, Composer 4.5, Houdini 2.5, and all of our in-house proprietary code. Our in-house code of course, was worked on by our software department over the last three years, improving and adding features.

This was Imageworks first foray into character animation. By the looks of it, the results are rather good. It really paid off to have determined and focused planning in the beginning, along with an absolute top notch crew.

This film could never have been made, and Stuart not realized, were it not for the incredible team of producers – Debbie Denise, Michelle Murdocca, Lydia Bottegoni, and Audrea Topps-Harjo. Because the production pipeline had so many steps and so many details, these four allowed the Supervisors to supervise, the artists to be artists, and the Visual Effects Supervisors to concentrate on the big picture of consistency and quality in the final delivery of the film.

Supporting virtually everyone on the digital team, and working with Imageworks' Systems Department was Jody Echegaray. He kept the flow of work at 100% all the time. Juggling a show that had so many unknowns took a great deal of patience, planning, and pure street smarts. Plus, his sense of humour kept everyone laughing – even when they weren't supposed to.

Most importantly, much credit is due to the large group of technical directors and artists who put in tireless hours. Without their incredible technical and artistic abilities the film would never have reached the level of quality it did.

The entire studio from the Systems Department to Accounting to Janitorial to Editorial all helped in the creation of this film. Though not everyone received a film credit, everyone on the film contributed in their own very important way.

The Future

The future of digital characters is so bright, it's practically blinding.

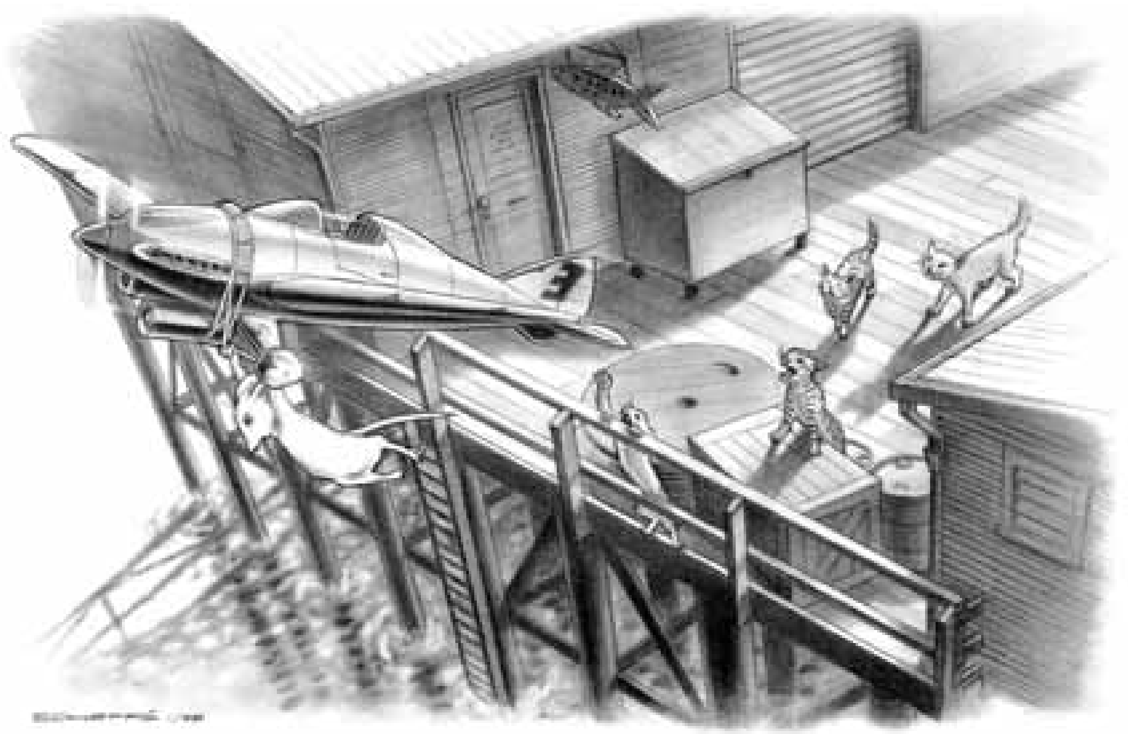
Digital characters have become more commonplace and more convincing in the recent years. Hardware and software have fallen in price to a point where most anyone can acquire them. As the tools become less relevant, the talent and genius of the artists and users will be the most important asset to a studio.

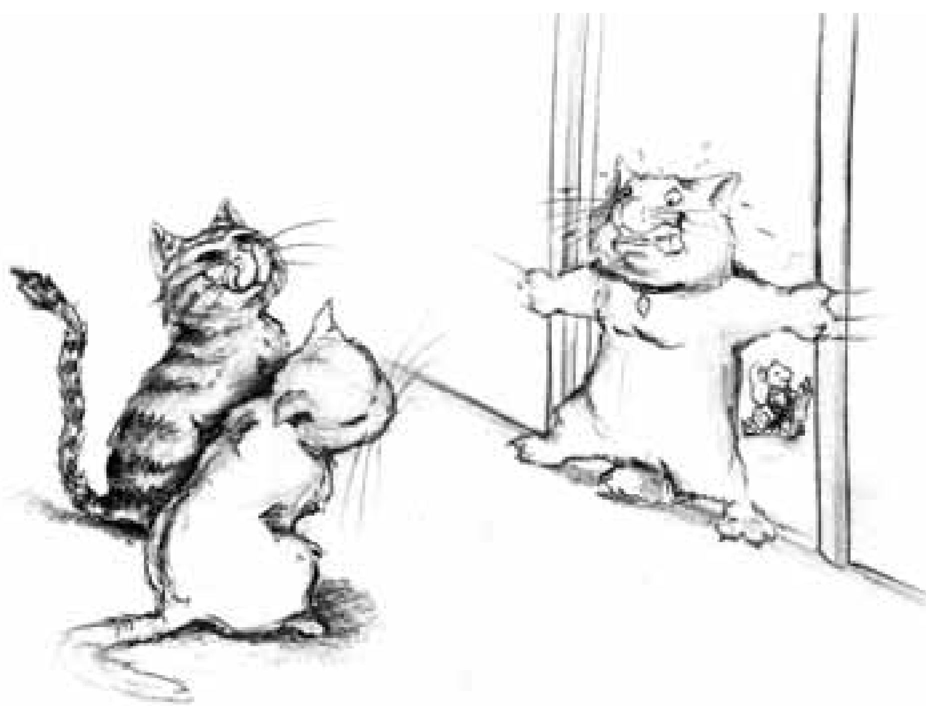
In the near future the trend of "content creation" will become more important.

"Stuart Little" is an example of a studio-driven film that succeeds in it's content - that "content" being Stuart himself. As an actor and character, Stuart has personality, emotions, and feelings. Avoiding the pun, Stuart is a real three-dimensional character. This is what people relate to. While human beings will always want a story of the fantastic and otherworldly, there is a longing for characters they can relate to. While Stuart is not a person per se, he holds the qualities of an inspirational human being – that is what viewers find so attractive.

It will be interesting to see other digital characters and actors come and go. Like the popularity of human actors, the success they achieve is had by the roles they pick, the films or television programs they do, or by what they say in an interview. Sometimes their popularity shifts simply by what they wear to an awards event.

The future looks populated with digital actors, both in and out of live-action feature films. One day, a digital character could be up on stage accepting his or her award, maybe even wearing a trashy dress. The day that digital character's dress gets reviewed in a "Best/Worst Dressed" column, everyone will know *they've arrived.*





Course #14, SIGGRAPH 2000
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Stuart Little: A Tale of Fur, Costumes, Performance, and Integration: *Breathing Real Life Into a Digital Character*

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