Making Mrs. Incredible More Flexible

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Figure 1: Helen Parr a.k.a. Elastigirl a.k.a. Mrs. Incredible ©Disney/Pixar. All rights reserved.

ABSTRACT

In Pixar's Incredibles 2, Mrs. Incredible was once again tasked with using her power of elasticity to help those in need. Advances in technology since the first film came out nearly 15 years ago, coupled with increased audience sophistication and finer scrutiny to detail, demanded that stretching the model, shading and garments look more believable than in the previous movie. Helen's wide range of actions takes a more prominent role in this film, and it was often times close to camera. To address these potential issues, new techniques had to be developed and new processes added to our Cloth, Shading and Rigging pipelines.

CCS CONCEPTS

•**Computing methodologies** → *Mesh models; Texturing; Physical simulation;*

KEYWORDS

stretching, rigging, shading, garments, clothing, texture spaces

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1 ELASTIC RIG

Mrs. Incredible was animated in the original Incredibles by utilizing seven different rigs and multiple model topologies. For this film, the decision was made to approach all civilian and superhero actions with one model and one rig to allow for savings in downstream departments such as Shading, Groom and Animation. This decision meant that Helen had to be able to switch between a stretchy, curve-based rig and a more traditional skeletal rig within a shot. The ability to toggle elasticity by regions, such as for an arm or the torso, further complicated the hybrid rig.

The elastic portion of Helen's rig was built upon the AutoSpline technology developed for Hank the Octopus in Pixar's Finding Dory [Talbot et al. 2016]. Like Hank, the director wanted Helen's limbs to be able to spiral around objects, which she couldn't do easily in the first film. However, unlike Hank, Elastigirl's arms had to extend many times their default length and her elastic regions had finer details than Hank's arms. Hank's arms were also controlled solely by a hierarchy of splines, while Helen had both bones and curves. Knots in Helen's curves are initially constrained to her bones, but can be detached and repositioned as needed. To make seamless switching from a skeletal-based to a curve-based deformation, knots could have broken tangents to closely approximate the actual skeleton and then transition into a smoother shape over a few frames. Corrective shapes for transition areas such as the wrist or shoulder were reused between both the skeletal and spline portions of the rig, but the angles used as inputs to the shapes were calculated differently between the two portions. The wrist angle, for example, was calculated between the lower arm bone and the hand bone for the skeletal rig, but it was calculated between the spline and hand bone for the elastic arm rig. Additionally, all hints of musculature and bone protrusions had to be removed as regions stretched to get clean, graphic silhouettes.

Parachute, trampoline and other flattened variations of Mrs. Incredible also had to be integrated within her skeletal rig. Flattening Helen was done with various scales early in her deformation hierarchy and by translating her limbs apart to the desired size of her torso. Torso deformation was controlled by proxy geometries that represent the planar nature of her large, sheet-like shapes needed throughout the film. Additional AutoSplines that conformed with the edges of the proxy geometry presented extra, finer detailed control to the animators to influence silhouettes.

2 STRETCHING SHADING

When Elastigirl's model is stretched or reshaped, any texture detail is also stretched out. In the first film, the parts of her that stretched hardly had any noticeable texture pattern detail, thus not causing any undesirable stretching artifacts. In Incredibles 2, however, the clothes she wears while stretching have more details. A design goal of the original red super suits was to bring out more detail than was possible in the first film. Furthermore, Elastigirl spends a considerable amount of screen time in a new suit that has a very distinct weave pattern. When stretched out, the weave patterns create shapes that make her shading look broken rather than like stretched fabric. To fix this problem and make the weave patterns look more natural when stretched, a few different *uv* based solutions were needed. Various factors determined which solution was most effective for each case, including the poses she stretches into, her position relative to the camera, and how quickly she moves.

We discuss which methods were most effective for which cases. All of the textures affected are *uv* based, so each solution manipulates the *u* and *v* parameterization of the object. The simplest cases were when Elastigirl stretched into poses where her whole body stretched almost uniformly both vertically and horizontally, resulting in the weave pattern looking too large. A simple fix was to uniformly scale the *uv* manifold for the pattern, effectively increasing the frequency of the weave. A slightly more complex case, however, was when isolated sections of her body stretched in one direction. For example, she often stretches out her arms while the rest of her body remains normal. In this case applying a uniform *uv* scale over the whole garment would not be adequate. Since her arms stretch only along their length, only a scale along the same direction as their stretching is needed. Furthermore the *uv* stretching is isolated to only the arms *uv* section so as not to affect the rest of her body that does not stretch. Even more complicated cases arose when she stretched her body parts into shapes that cannot be compensated with *uv*-aligned scales. Methods such as scaling *u* and *v* with varying primvar sets and calculating *uv* scales using derivatives of the stretching mesh points with respect to a reference pose were attempted, but either did not provide pleasing results for more than just a couple corner cases or were time consuming to setup for each type of stretch pose. A far better solution more applicable to a wider range of poses was using custom *uv* maps. A new *uv* map was created for a stretched pose and then the input texture manifold blended between the original and new *uv* maps. The same custom *uv* map could be reused for a variety of different poses throughout the film by blending towards the new stretched map and targeting the blend to specific body areas using face sets.

3 EXTENDING CLOTH

The development of Helen's various super suits came with challenges for Art and Characters in the production of Incredibles 2. Staying true to the original design while also making improvements were important requirements during the development stages. Improvements included modeling the rendered suit using quads, adding subtle features like seams and thickness, and making elements of the suit modular. Modular suit elements allowed us to create multiple variations of the super suit from a single model that could be used in different parts of the film. This modular approach allowed for flexible maintenance and reuse of the suit's cloth rig and simulation setup with minimal impact on production schedule.

Stretchy Helen presented a set of challenges to the super suit. For example, the design of the emblem had to remain stiff and not stretch for the majority of poses in the film with the exception of the trampoline and parachute poses. We developed a solution that uses the 3D deformed pose to determine the *uv* shape of each triangle. Internally the shape of the triangle in the *uv* space is modified to match the shape of the triangle in world space while preserving the original 2D *uv* alignment as close as possible. In order to achieve the desired look, the set of triangles defining the emblem region were locked while the surrounding triangles used 3D *uv* scaling to stretch and scale with respect to the kinematic points. This solution allowed the super suit to stretch while keeping the emblem intact. Other segments of the suit (such as bodice, sleeves, and pant legs) made use of the 3D *uv* scaling to handle exaggerated stretching and compression of the suit without distorting the emblem.

Figure 2: Emblem before and after 3D *uv* scaling ©Disney/Pixar

Incorporating 3D *uv* scaling into our workflow required that the underlying deformed mesh supplied to the simulator was clear of artifacts in both standard poses and exaggerated poses. As a result, extra effort went into the rigging of the garment to produce a robust cloth warp. Our method involved using a combination of deformers to produce clean poses of the suit before simulation. One problematic region discovered during the development stages of the suit was the briefs' leg holes and how they responded to tight areas of contact. A rig for the leg holes was created to obtain the desired shape of the holes and make the suit more robust.

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