Shading Rig: Dynamic Art-Directable Stylised Shading for 3D Characters (Supplemental Material)

LOHIT PETIKAM, Computational Media Innovation Centre, Victoria University of Wellington, New Zealand (NZ)
KEN ANJYO, OLM Digital, Japan and Computational Media Innovation Centre, Victoria University of Wellington, NZ
TAEHYUN RHEE, Computational Media Innovation Centre, Victoria University of Wellington, NZ

1 LOCAL TEXTURE SPACE DISCUSSION

Our local texture space was designed to achieve the fill light behaviour [Landau 2014] described in Section 3. We considered the method of Todo et al. [2013] which allows artists to define shading on a lit-sphere texture. This has the benefit of lit-sphere edits automatically moving with a changing light direction. However, editing a lit-sphere texture will affect other surface points that share the same normals as the selected region (see Figure 1). Instead, we need to able to select a local area on the surface to be edited.

While 3D software provide texture projection interfaces for local decal placement [Schmidt et al. 2006], we implement a simple texture space behaving similar to point lighting. Specifically, this allows our parametric distribution (Section 4.1) to exhibit light intensity falloff based on distance, to match the fill light paradigm.

We note that our simple projection cannot handle repeated and high curvature. The edit shapes would be repeated on the behind surface that curves away from the point source. Discrete Exponential Maps [Schmidt et al. 2006] would solve this issue, but is dependent on mesh topology and becomes slow for large projections over many triangles. In our case, the Normal Smooth (τ) or Radius (R) parameters should be reduced to mitigate the issue.

2 SYMBOLS AND NOTATION

Table 1 includes all symbols and notation used in Section 4 of the paper, and Section 1 of this supplemental document.

3 SHADING INTERPOLATION RESULTS

Figure 3 shows how our parametric approach achieves true distribution interpolation. This preserving continuous shading interpolation between keyframes, compared to the method of Todo et al. [2007].

Figure 2 compares shape interpolation running times of Nader and Guennebaud [2018] with ours. We can see that our shape interpolation is an order of magnitude faster.

4 INFORMAL USER FEEDBACK

We implemented the Shading Rig prototype interface as a Maya plugin. We showed this to several artists to assess the potential of industry usage and compatibility of our method. In our prototype, the artists could freely edit toon shading on a stylised model with our method. We received feedback from a technical artist from a Japanese animation company producing world-renowned 2D cel animation and 3D cartoon films. We also consulted 3 professional 3D artists and 7 graduate students in 3D animation and visual effects. We gave all the artists the task of using our prototype to match the reference animation shown in Figure 16 in the paper. However, they could design different animations to test other aspects based on

Table 1. Symbols and notation.

Symbol	Definition
a	Anisotropy
s	Sharpness
w_y	Bend
w_x	Bulge
θ_r	Rotation
τ	Normal Smooth
d	Softness
G	Intensity Gain (for Intensity edits)
R	Radius of influence for a given edit
$\mathbf{p}_l$	Edit position / light position
$\mathbf{p}_o$	Light origin
(u, v)	Local texture space coordinates
$\mathbf{p}_w$	World position of shading point
$I(x, y)$	Intensity distribution function
α	$\alpha := 1 - a$
(u_w, v_w)	Warped texture space coordinates
$\mathbf{w}$	$\mathbf{w} := (w_x, w_y)^\top$
$\mathbf{u}$	$\mathbf{u} := (u, v)^\top$
$\theta_w(\mathbf{u})$	Warping function
k_w	Warping coefficient for θ_w
$\boldsymbol{R}(\theta)$	2D rotation matrix for angle θ
$c(\theta)$	Mask to remove repetitions from warping
$f_s(x)$	Distance fall-off function
k_s	Step-edge width for $f_s(x)$
ω	Attenuation factor based on distance fall-off
$\mathbf{N}(\tau)$	Smoothed normal vector of shading point
$\mathbf{n}$	Surface normal vector of shading point
γ	Attenuation factor based on $\mathbf{N}(\tau)$
$\mathbf{v}$	Direction vector from $\mathbf{p}_w$ to $\mathbf{p}_l$
$\mathbf{p}_c$	Centroid of surface mesh
d_0	Existing reflectance from conventional lighting
N_I	Number of Intensity Edits in the shading rig
T_0	Global toon shading threshold
$\mathbf{B}_1$	Lit region on surface
$\mathbf{M}$	Mask region of a given Mask edit
t_m	Threshold to produce the mask $\mathbf{M}$
N_M	Number of Mask edits in the shading rig
λ	Spherical Gaussian kernel width
$\boldsymbol{\eta}$	Direction vector parameter to sample the spherical Gaussian
ξ	Center axis of the spherical Gaussian
$[\mathbf{l_x l_y l_z}]$	Light space
$\mathbf{v_l}$	Light space vector

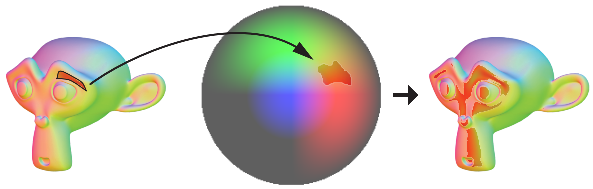

Fig. 1. Limitation of lit-sphere approach [Todo et al. 2013] for artistic editing. Left: Artist-specified local area on 3D model where shading must be edited. Middle: corresponding area on lit-sphere domain where the stylisation texture would be modified. Right: affected area when applying the edited lit-sphere texture is far greater than the specified region.

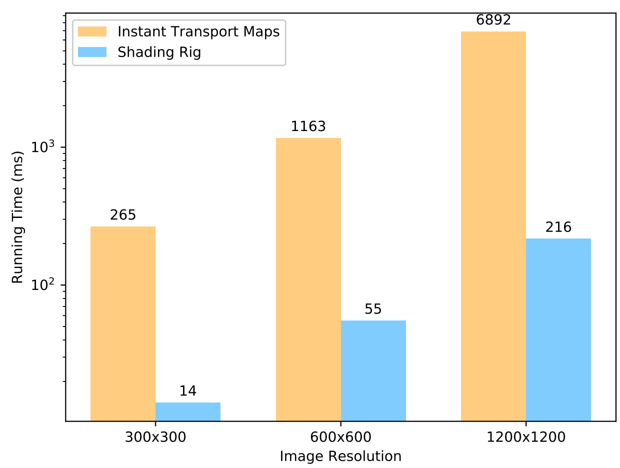

Fig. 2. Shape interpolation running time comparison (log scale) between [Nader and Guennebaud 2018] and our model, using non-parallelised CPU implementations of each method to compare number of operations.

their own requirements. All artists were proficient with animation in Maya.

Industry Technical Artist. The 3D technical artist from the animation company had expertise in 3D toon shading and editing practices. Regarding industry adoption he commented "Using this tool, shadows and highlight areas can be edited before rendering of the shots. Thus eliminating the need for editing the light and shadow areas in post using techniques such as rotoscopy". This verifies our intended use case of pre-animating the shading rig for directed shading without artist intervention. Regarding the visual results of the tool, he confirmed our model produces a sufficient range of shapes for toon shade editing tasks, and said that it "produces simplistic shape results which are pleasing to the eye". One interesting concern he raised was that "to achieve the desired result the shading rig needs to be animated. Which is not the specialisation of a lighting artist so it may produce confusion in delegation of work".

Professional 3D Artists. One 3D artist could see potential in designing "3D character model sheets" with our method, expressing that the shading rig's ability to "propagate shading rig changes through all shots at once" would be very useful. This artist also mentioned it "gives fast exploration, with a strong, continuous, instant feedback loop", and that artists "can get started with editing immediately during 3D lighting stage, instead of waiting for clean-up at post-production". The artists said our edits were easy to control and intuitive. They were able to shape and animate edits within minutes. Regarding the visual results, they confirmed the edit shapes looked natural.

Graduate 3D Students. The students had between 5-8 years prior 3D industry experience. In general students agreed it was easier to gain a similar appearance to a reference example. Some students expressed that controlling and animating our parameters can be tedious and requires some time to learn. However, given our results showing shading animation with fewer keyframes and no precomputation time, the shading rig can save asset pre-production time.

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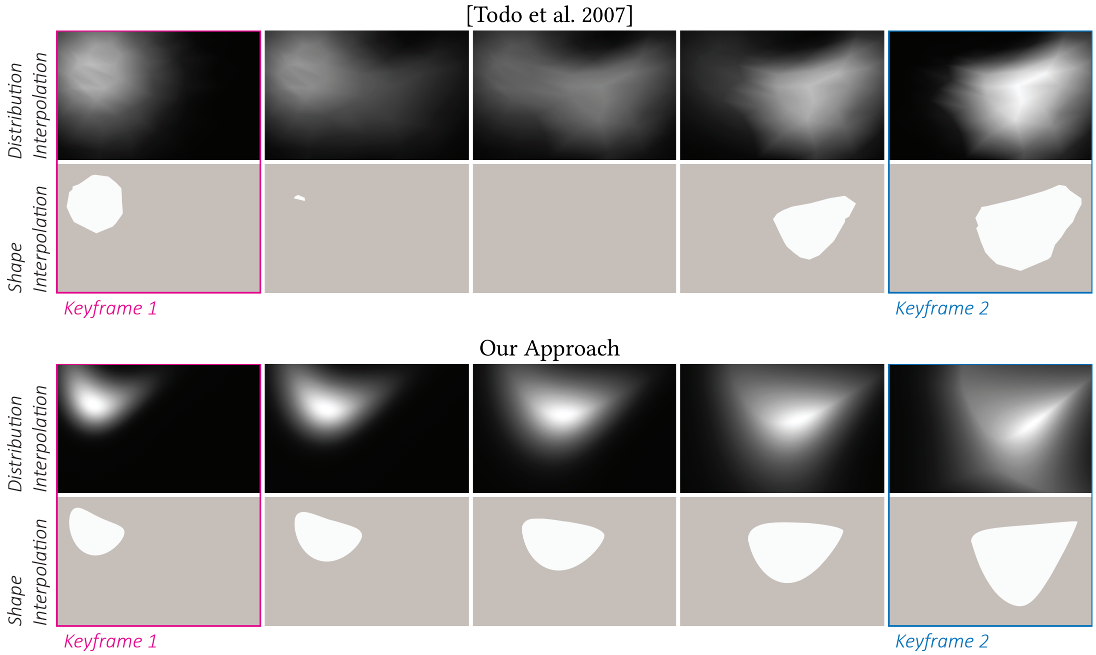

Fig. 3. Intensity distribution interpolation with the method of [Todo et al. 2007] (top) and our approach (bottom) on a mesh surface. Todo et al. [2007] linearly blend between fixed distributions, causing shapes to disappear and reappear between two keyframes (left-most and right-most images). Our Shading Rig parametrises the distribution for true shape movement and interpolation. Note that precisely matching the shapes of Todo et al. [2007] with ours is limited by mesh topology.