

# Dynamic Stylized Shading Primitives – Supplemental Material

David Vanderhaeghe  
IRIT - Université de Toulouse

Romain Vergne  
University of Giessen

Pascal Barla  
INRIA

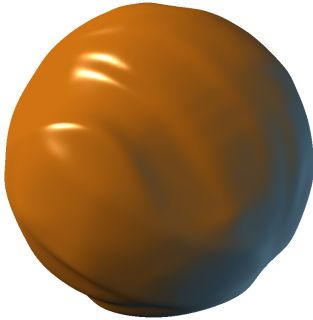
William Baxter  
Google

In this document, we present a pilot study conducted using our prototype system in Section 1. We then discuss our choices of specular effects and show shape-based color variations in Section 2. Finally, Section 3 illustrates extensions of our model that permit to create more complex primitive shapes.

## 1 Pilot study

We performed a pilot user study on three non-authors and two authors (one not familiar with the UI) to get an idea of the usability of our system. The goal was *not* to evaluate any particular UI, but rather to test whether the control of shading primitives would reveal any interaction flaws *despite* the obvious limitations of our prototype implementation. For each user, we spent five minutes explaining our prototype user interface. Users were then free to experiment with primitives and their parameters for ten minutes. After that, users were asked to reproduce the simple rendering shown in Figure 1, with a time limit of fifteen minutes. Finally, they went through a questionnaire, for which results are listed below.

- **Familiarity with shading editors:** Three users out of five were familiar with shading editors.
- **User interface:** Three users found the user interface intuitive, but the choice of shortcuts to edit profiles awkward. One of them would have preferred text instead of icons, and the last user disliked the UI.
- **Manipulating isocurves vs profile function:** Four users out of five preferred using the profile function, and found it very intuitive. One of them used isocurves half of the time.
- **Creation of a primitive:** All users found the entire process for creating a primitive simple and intuitive.
- **Different parametrization:** Two users found that manipulating diffuse primitives ( $\alpha = 0$ ) was more difficult. Two other users found specularities ( $\alpha = 1$ ) harder to use. One user did not have any issue with any primitive type.
- **Surface features:** All users found them efficient and useful. Two out of five found parameters too sensitive.
- **Quality of reproduction:** Two users could reproduce accurately the presented rendering. Two other users came very



**Figure 1:** This rendering is obtained with three layers: a diffuse orange primitive, a white specular highlight and a blue backlight.

close to the reference. One user obtained an intermediate result (no highlight).

All the remarks made by users after the study concerned the UI, especially shortcuts. We believe that one reason why users did not manipulate isocurves overall is because they required an unintuitive handling of keyboard shortcuts. The slight difficulty experienced with diffuse primitives might be due to the reference result we chose, which is mostly diffuse. The difficulty experienced when manipulating specular primitives might be due to the fact that only the light direction is manipulated, not the reflection direction.

This pilot study suggests improving the UI, especially shortcuts. However, even with our prototype UI and its obvious drawbacks, users were able to finish or get close to completion in fifteen minutes trials or less (one user, not familiar with the UI, reproduced accurately the rendering in four minutes). From these preliminary results we are able to conclude that a primitive-based approach to stylized shading design does not reveal any serious interaction flaws. In a more production-oriented version of the system, a special care should be paid to the UI, but we believe this is not specific to our primitive-based approach.

## 2 Parametrization and color variations

Our shading parametrization is based on the reflected view vector  $\mathbf{r} = 2(\mathbf{v} \cdot \mathbf{n})\mathbf{n} - \mathbf{v}$  rather than the half vector  $\mathbf{h} = \mathbf{l} + \mathbf{v}/\|\mathbf{l} + \mathbf{v}\|$ . By default, this does not take the geometric term  $(\mathbf{n} \cdot \mathbf{l})$  into account. In contrast, using the half vector makes the introduction of the geometric term mandatory, since  $\mathbf{h}$  is not defined when  $\mathbf{l} = -\mathbf{v}$  as shown in the top rows of Figure 2. For completeness, we also provide the ability to re-introduce the geometric term in our parametrization, as seen in the bottom rows of Figure 2. All specular behaviors are shown in the isotropic and anisotropic cases.

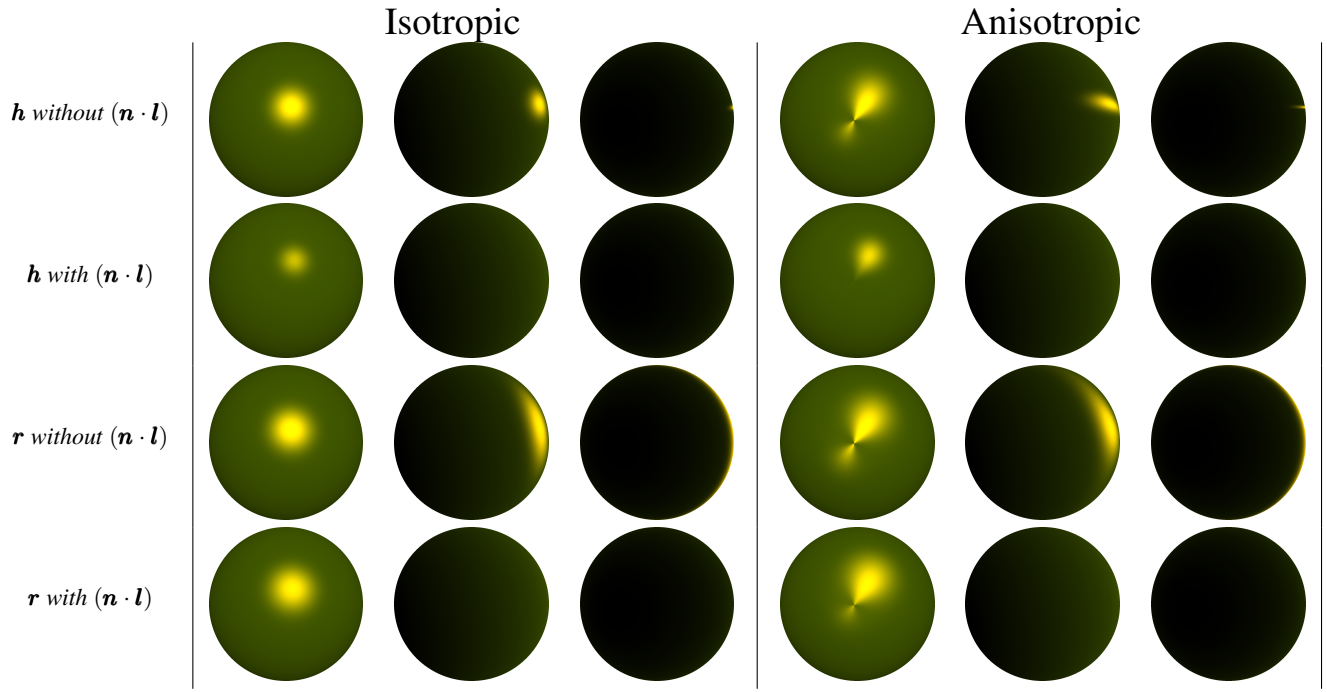
Figures 5 and 6 show how  $\alpha$  changes anisotropic variations. The more  $\alpha$  tends to 1, the more anisotropy is taken into account.

Our shading primitives may be manipulated to convey concave and convex surface features in two different manners: by offsetting their parametrization toward or away from concavities or by blending between a pair of color ramps. If we mainly make use of the former approach, the latter sometimes proves to be useful, although it tends to produce different material percepts. This is illustrated in Figure 3, where each enhancement is shown separately and then combined. Figure 7 presents variations of the two surface feature controls we use:  $\mu$  and  $\chi$ . Color ramp produces more complex color variations as presented in Figure 8.

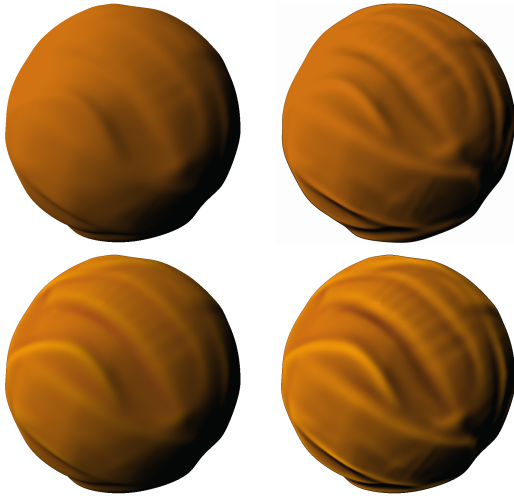
A set of intensity profiles is shown in Figure 9.

## 3 Extensions

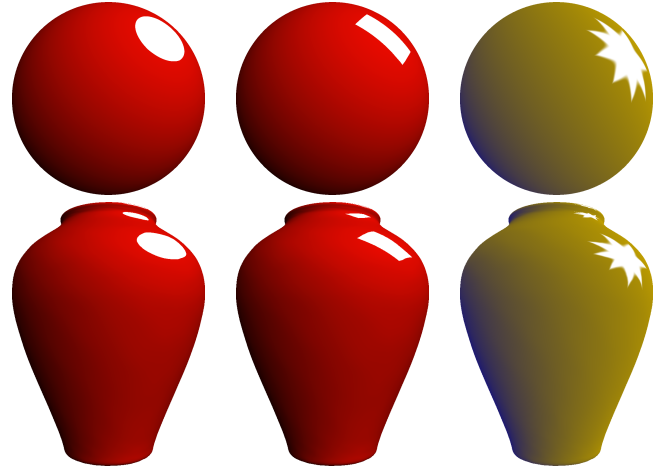
We have made some simple extensions to the model presented in the paper in order to reproduce previous techniques. The main addition to the model is the ability to apply transformations to each primitive's parametrization, in order to modify the shape of the shading functions. In Figure 4, we show results obtained with the squaring and rotation transforms as in the work of Anjyo et al., and a star-shaped highlight as in the work of Pacanowski et al..



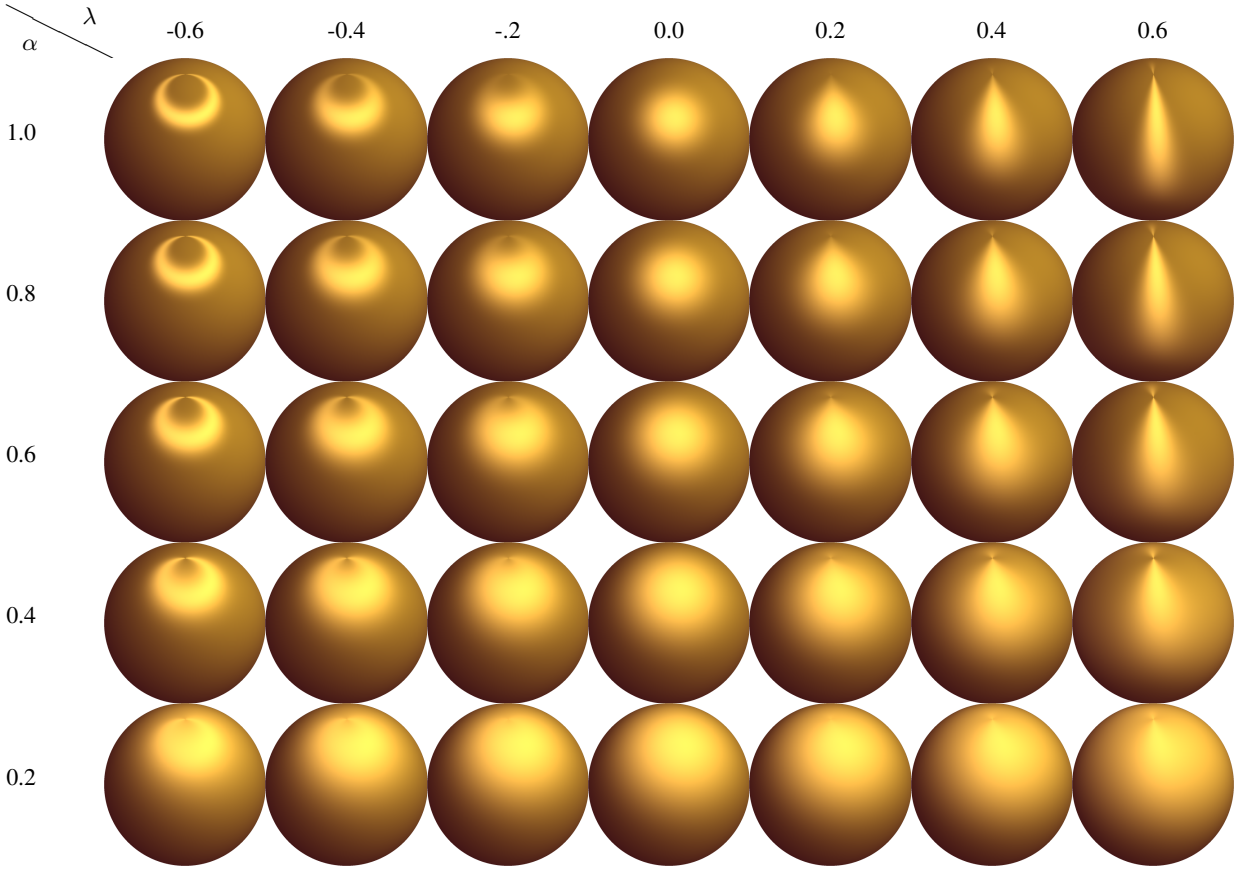
**Figure 2: Parametrization choices for specular effects.** The first two rows demonstrate that when using the half-vector  $\mathbf{h}$ , the geometric term  $(\mathbf{n} \cdot \mathbf{l})$  is required to prevent artifacts when  $\mathbf{l} = -\mathbf{v}$ . Such artifacts are enhanced in the anisotropic case. The third and fourth rows show that using the reflected view vector  $\mathbf{r}$  for specular effects, we do not obtain such artifacts both in isotropic and anisotropic cases, even when the geometric term is not included. Note that in the anisotropic case without geometric term (third row), we use the back-lighting term  $(\mathbf{l} \cdot \mathbf{v} + 1)/2$  to avoid artifacts when  $\mathbf{h}$  is not defined as explained in the paper.



**Figure 3: Shape enhancement.** Top left: a single orange diffuse primitive conveys surface features poorly. Top right: shape-based intensity offsetting attracts shading on convexities and repels it from concavities. Bottom left: shape-based color blending turns its color toward yellow in convexities and red in concavities. Bottom right: combining both effects produces a vivid depiction of shape.



**Figure 4: Complex primitive shapes.** In red: the rotation, scaling and squaring of highlights as in previous techniques by Anjyo et al. are obtained by a simple extension of our model. In green: with an additional star-shape transform, we reproduce results similar to Pacanowski et al.



**Figure 5:** Variations of anisotropy ( $\lambda$ ) and behavior ( $\alpha$ ) are presented here. When a primitive has a reflective behavior ( $\alpha = 1$ , top row)  $\lambda$  is fully taken into account for anisotropy. Moving the primitive toward a diffuse behavior ( $\alpha < 1$ ) reduces the impact of anisotropy.

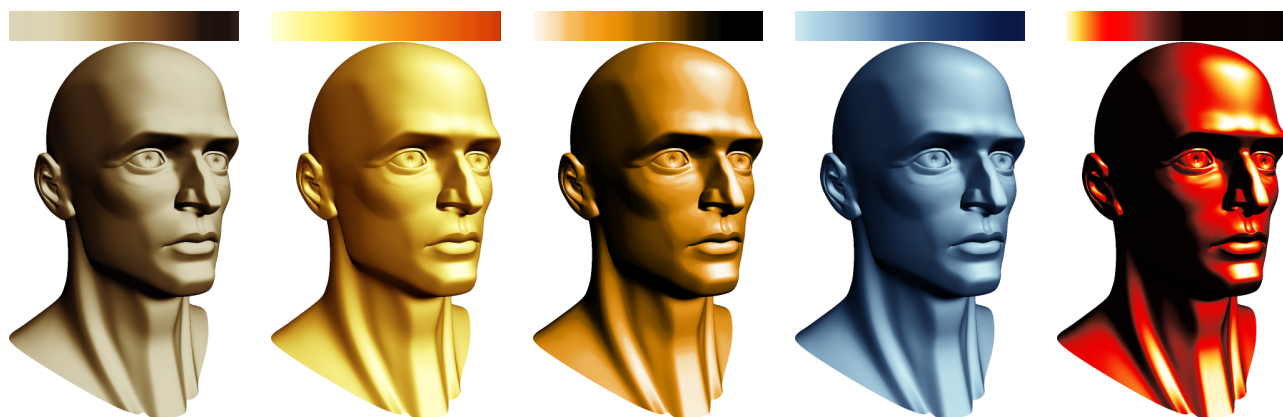


**Figure 6:** Same as Figure 5 with a complex model. Here the tangent field is computed only from vertex coordinates, as in the sphere example, but any vector field defined on the surface might be used.

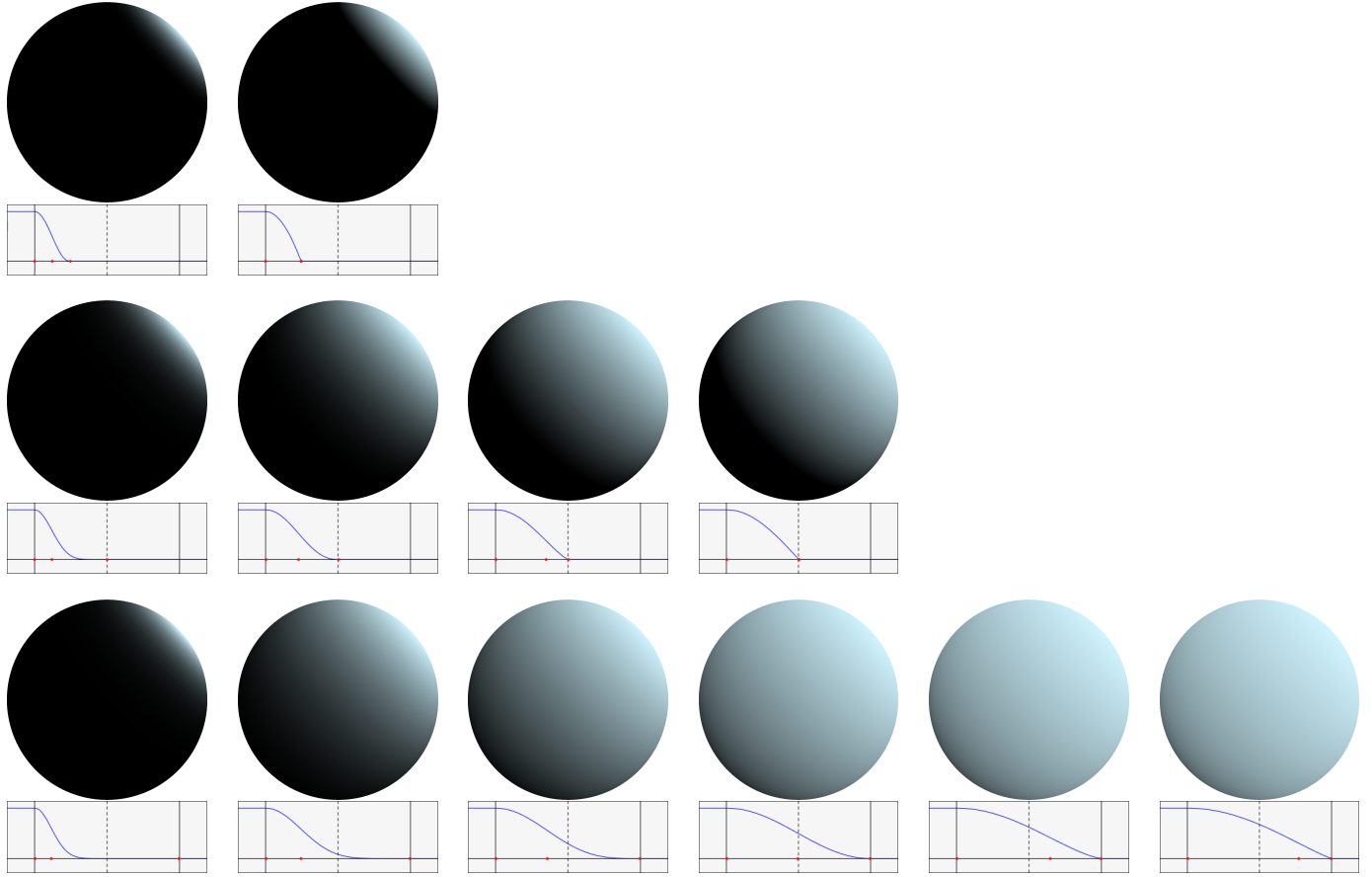




**Figure 7:** Varying surface feature enhancement. The strength of the effect depends on the slope  $\chi$ . The central column ( $\mu = 0$ ) changes only primitive color in concavities and convexities. Positive values of  $\mu$  attract primitive on convexities, in red, and repel primitive from concavities. Negative values of  $\mu$  attract primitive in concavities, in yellow, and repel primitive in convexities.



**Figure 8:** Using a color ramp (top row) produces complex color variations. Only one primitive is used here.



**Figure 9:** Profile variation is shown on a sphere with one light blue primitive. Cutoff parameter is  $c = \pi/4$  (first row),  $c = \pi/2$  (second row) and  $c = \pi$  (third row). Falloff increases by steps of  $\pi/8$  in each column. Under each sphere, there is a plot of  $I$  (vertical bar at 0 and  $\pi$ , dashed bar at  $\pi/2$ ).