Real-Time Rocks: Shader-Based Labradorite

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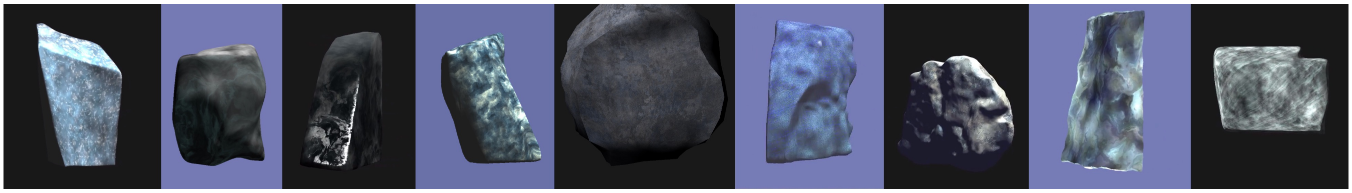

Figure 1: Groovy work submitted by Paul DeBaun, Cassidy Lamm, Philip Hatfield, Chris Cornejo, Kunta Lowe, Erik Reed, Walt Fulbright, Thad Wassynger, and Sarah Martin, left to right respectively, for DPA 8090: Rendering & Shading.

ABSTRACT

Great assignments in computer graphics rock! Being slated to complete something concrete that engages interest and provokes solid personal development while not being completely set in stone is a monumental experience. Mining ideas for learning graphics, representing something visually complex such as labradorite can be unearthed as a gem of an assignment, and one can learn a fragment of shading while procedurally chipping away at the assignment.

CCS CONCEPTS

• **Computing methodologies-Computer graphics: Rendering**;

KEYWORDS

CGEMS, rendering, shaders, procedural generation

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1 OVERVIEW

The goal of this assignment is to encourage creative exploration of graphics and the real world while developing technical and aesthetic skills. Students are each given a stone of labradorite, a very interesting substance [V. Raman and Jayaraman 1950] [Weidlich and Wilkie 2009], along with a matching turntable video. They are then asked to match the visual qualities of their specimen using procedural shading techniques. In this case it is implemented within a real-time pipeline, particularly a fragment shader within OpenGL 4.x to keep things current and platform independent. Having reviewed pertinent mathematics, learned basics of shading models, practiced some GLSL development, and studied procedural techniques, students practice an open problem while bringing a variety of concepts together for a nifty assignment – one that is hands-on, fun, and challenging but built to reward students' attempts at exploration and personal development. Figure 1 includes some single frames of final submitted renders, all shaded in real-time with procedural techniques implemented using GLSL.

1.1 Inspiration

Modeling natural phenomena is useful for visual effects, game development, and scientific simulation. There are a variety of captivating objects such as minerals, plants, and animals that have interesting visual properties to study and model. The mineral labradorite, a type of feldspar, has such compelling optical properties. Gaps of parallel layers within the rock yield iridescence, reflecting bright blues and greens from different viewing angles [V. Raman and Jayaraman 1950]. Intriguing visuals such as these can inspire everyone practicing computer graphics and promote interest in other fields. Studies have also focused on rendering labradorite, its iridescence, and other gemstones with metallic glitter [Weidlich and Wilkie 2009]. State-of-the-art work in rendering investigates advanced light transport properties related to iridescence and diffraction [Belcour and Barla 2017] [Dhillon and Ghosh 2016], and thus challenging students to practice a related assignment at a simpler level can open a variety of worlds including ongoing research and development.

1.2 Background Preparation

This assignment originated as part of a module in a graduate-level rendering and shading course but could be scaled easily for a variety of levels. Prior to this students build skills by completing a short review of graphics-related math, implementing Blinn-Phong shading using GLSL, and practicing mapping functions and other basic procedural techniques. Voronoi partitioning, Perlin Noise [Perlin 1985], and fractal Brownian motion (fBM) are covered to give students a toolset to consider using in their exploration. Some excellent resources that could be considered for class or student use include the interactive websites *The Book of Shaders* [Vivo and Lowe 2015], *Scratchapixel* [Scr 2016], and *GLSLViewer* [gls 2016] as well as the books *Graphics Shaders: Theory and Practice* [Bailey and Cunningham 2011] and *OpenGL Shading Language* [Rost and Licea-Kane 2009].

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2 MATERIALS

Students are given a stone of labradorite to study and observe along with a video of the same revolving on a turntable lit primarily from one direction. See the right side of Figure 2 for an example. Unpolished stones were given, but polished stones, other types of minerals, or other specimens of interesting materials could be given instead. As an alternative to distributing stones, students could be asked to visit the nearby geology museum and photograph an interesting specimen. Whatever phenomenon is assigned, some engaging research of another field could be promoted.

A documented package of platform-independent (setup to build easily on Linux, Mac, or Windows), OpenGL-based C-code with GLSL shaders is provided. The code includes an example of multi-texturing implemented on a teapot animated in a real-time turntable that matches the rate of their video turntable. The example also has commented vertex and fragment shaders implementing a Blinn-Phong shaded, single-light environment (essentially a working solution to what was a previous assignment). Students are asked to explore various attempts to see how visually close they can match the surface appearance of their individual labradorite stone.

2.1 Assignment Objectives

Summary of objectives:

- Observe individual stone given and complete a model (using software such as Maya) with texture layout to match.
- Export model as an .obj file from modeling software to read within given OpenGL code.
- Develop a procedural fragment shader that uses discussed techniques or others to attempt to match given stone.
- Maintain Blinn-Phong or other BRDF shading in the fragment shader, shifting the light location to match the video turntable of given stone.
- Consider a layered approach informed by the texture coordinates, normal vector, view vector, and light vector.
- Match reference as best possible, but experimentation, technique, and visual style are valued above a perfect match.
- Include a description of your approach as well as a screenshot of any versions during development. Render a looping turntable and generate a video showing your attempt next to the given video of your piece.

Optional extensions:

- Implement your own noise, fractal Brownian motion (fBm), Voronoi, or other algorithm in your own code and document.
- Implement a more advanced version of coherent noise (such as simplex or other) to use in your shader.
- Manually paint layered maps to match your labradorite and compare against your procedural approach.

3 METADATA

See Table 1 for a high-level view of the assignment.

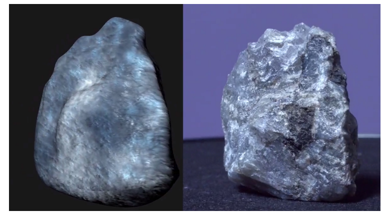

Figure 2: Video frame, procedurally shaded labradorite and original stone, submission by Austin Brennan.

Table 1: CGEMS Metadata for Shader-Based Labradorite.

Summary	Students practice technical and aesthetic skills while learning about shading, procedural techniques, and programmable graphics pipelines.
Learning Outcomes	Analyze visual properties. Design procedural techniques. Develop shader code. Assess render qualities.
Classifications	(3) Fundamentals, (4) Graphics and Interfaces: (a) GPUs, (7) Modeling, (8) Rendering.
Audience	Scalable from upper-level undergraduate, first graphics class to advanced graduate classes.
Dependencies	Some comfort with basic graphics-related mathematics and major concepts of programming.
Prerequisites	Works well as an assignment after ones that help review basic linear algebra, Blinn-Phong shading, and simpler procedural techniques within the context of a fragment shader.
Strengths	Flexibility and the challenge of studying and attempting to match something from the real world on their own.
Weaknesses	Challenge of attempting to match something from the real world on their own if lacking confidence to try.
Variance	Fewer or additional aids could be given, and a variety of other procedural techniques or shading models could be suggested or covered.
Assessment	Documentation of experimental development attempts; sophistication of techniques implemented; visual quality of renders.

REFERENCES

2016. GLSLViewer. http://patriciogonzalezvivo.com/2015/glslViewer/. (2016).

2016. Scratchapixel. https://www.scratchapixel.com. (2016).

Mike Bailey and Steve Cunningham. 2011. *Graphics Shaders: Theory and Practice* (2 ed.). CRC Press.

Laurent Belcour and Pascal Barla. 2017. A Practical Extension to Microfacet Theory for the Modeling of Varying Iridescence. *ACM Trans. Graph.* 36, 4, Article 65 (July 2017), 14 pages. https://doi.org/10.1145/3072959.3073620

Daljit Singh J. Dhillon and Abhijeet Ghosh. 2016. Efficient Surface Diffraction Renderings with Chebyshev Approximations. In *SIGGRAPH ASIA 2016 Technical Briefs (SA '16)*. ACM, New York, NY, USA, Article 7, 4 pages. https://doi.org/10.1145/3005358.3005376

Ken Perlin. 1985. An Image Synthesizer. In *Proceedings of the 12th Annual Conference on Computer Graphics and Interactive Techniques (SIGGRAPH '85)*. ACM, New York, NY, USA, 287–296. https://doi.org/10.1145/325334.325247

Randi J. Rost and Bill Licea-Kane. 2009. *OpenGL Shading Language* (3 ed.). Addison-Wesley Professional.

C V. Raman and A Jayaraman. 1950. The structure of labradorite and the origin of its iridescence. 32 (07 1950), 1–16.

Patricio Gonzalez Vivo and Jen Lowe. 2015. The Book of Shaders. http://thebookofshaders.com. (2015).

Andrea Weidlich and Alexander Wilkie. 2009. Rendering the effect of labradoescence. (01 2009), 79–85.