Isophotes of Approximately Continuous Surfaces

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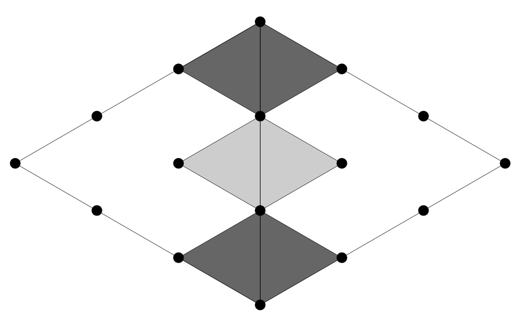
Abstract

Piecewise polynomial surfaces are created using patches and are designed to exhibit a certain level of continuity. Elaborate construction techniques exist to enforce the necessary continuity conditions. Alternatively, some applications that presently require a certain level of continuity may be able to use surfaces that almost achieve the desired level of continuity. Applications suitable for this include, but are not limited to, NC Machining, in which surfaces are only approximated in the first place, as well as computer animation. Several techniques exist to evaluate the quality of a surface and isophotes are suited to identifying discontinuities across patch boundaries. This work uses functional, triangular Bézier patches to build approximately continuous surfaces and then evaluates the surfaces using isophotes.

Continuity

Functional, triangular Bézier patches simplify the continuity conditions placed on surface construction. The following figure illustrates the conditions required for two neighbouring patches to meet with C^1 continuity.



- C^0 continuity requires coincident boundary control points
- C^1 continuity requires adjacent panels to be coplanar

Approximate continuity:

Two patches are said to join with approximate continuity of tolerance ε if the angle between the surface normals of the two patches at any point along the common boundary is less than ε. The resulting surface will be identified as being $\varepsilon - C^1$ continuous.

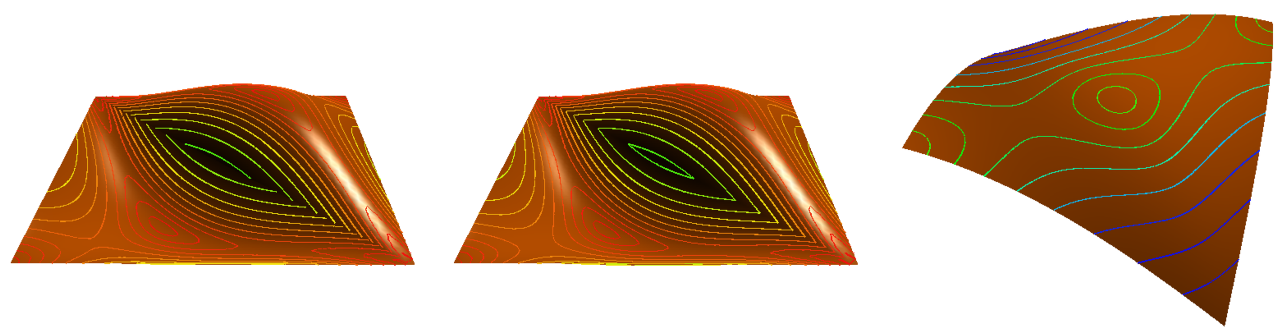
Quantity	Description
θ^{bound}	Maximum angle between corresponding normals along a single boundary

Isophotes

Isophotes are lines of constant diffuse intensity on a surface and are computed using

$$N(u,v) \cdot L = c$$

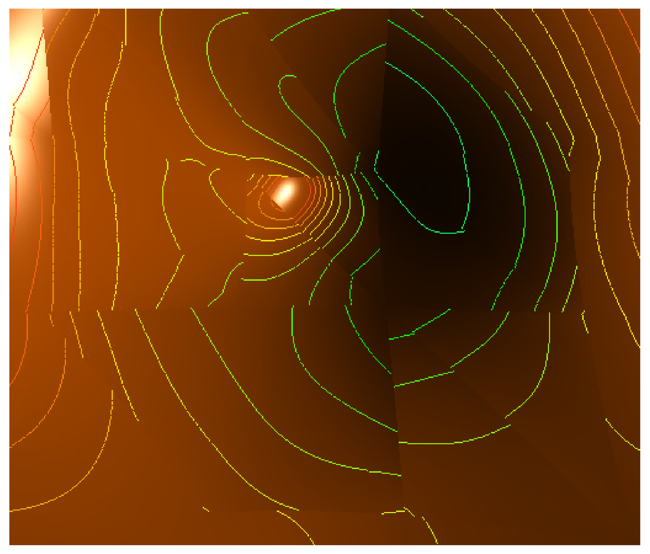
where $N(u,v)$ is the normal at a given point on the surface and L is the light vector. Isophotes are well-suited to identifying discontinuities on a surface because for a C^k continuous surface, isophote lines will be C^{k-1} continuous curves.



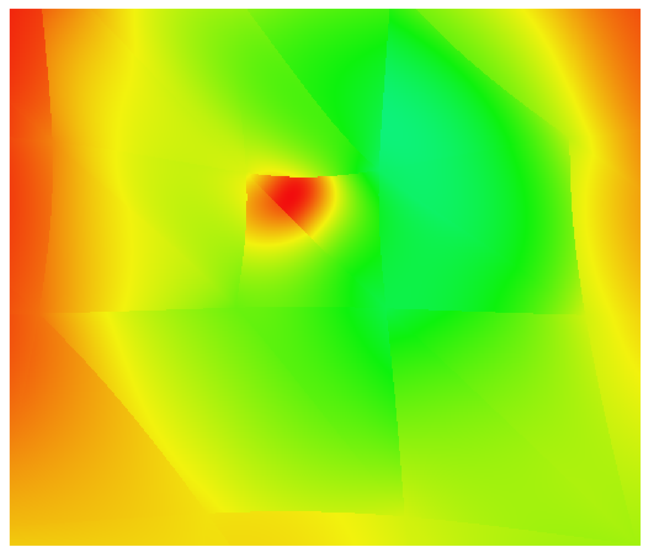
C^0 continuous C^1 continuous C^2 continuous

Shaders

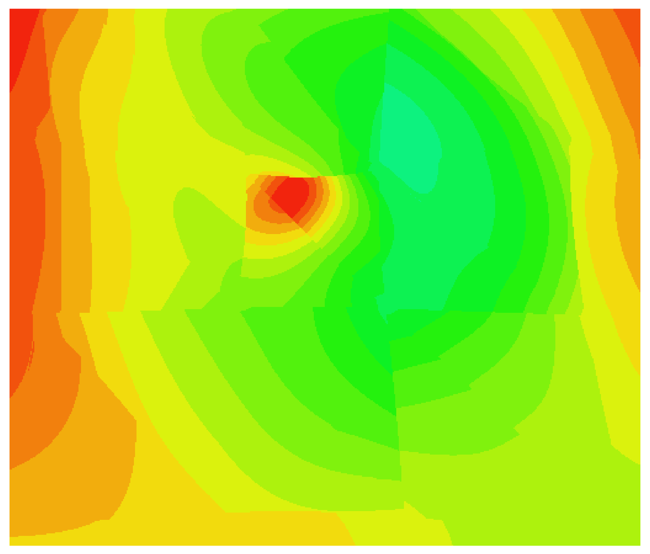
Three shaders based on isophotes are used to render the surfaces and identify discontinuities in the surfaces construction. Two of the shaders involve a non-linear mapping, similar to gamma correction, between the isophote value and a colour.



Line shader



False colouring shader



Range shader

Results and Pictures

To quantify the discontinuities across the surface, corresponding isophote lines are matched together. The distances between the isophotes are then measured and normalized to characterize the behaviour along each boundary.

Test surfaces: Samplings of 6 Franke functions over 10x10, 20x20 and 40x40 grid; constructed piecewise cubic surfaces are C^0 at boundaries, C^1 at corners.