Digital Surface Curvature

PhD Thesis
by John Rugis

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Department of Computer Science
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Abstract

The theoretical basis for this thesis can be found in the subject of differential geometry where both line and surface curvature is a core feature. We begin with a review of curvature basics, establish notational conventions, and contribute new results (on n-cuts) which are of importance for this thesis. A new scale invariant curvature measure is presented.

Even though curvature of continuous smooth lines and surfaces is a well-defined property, when working with digital surfaces, curvature can only be estimated. We review the nature of digitized surfaces and present a number of curvature estimators, one of which (the 3-cut mean estimator) is new.

We also develop an estimator for our new scale invariant curvature measure, and apply it to digital surfaces. Surface curvature maps are defined and examples are presented. A number of curvature visualization examples are provided.

In practical applications, the noise present in digital surfaces usually precludes the possibility of direct curvature calculation. We address this noise problem with solutions including a new 2.5D filter.

Combining techniques, we introduce a data processing pipeline designed to generate surface registration markers which can be used to identify correspondences between multiple surfaces. We present a method (projecting curvature maps) in which high resolution detail is merged with a simplified mesh model for visualization purposes.

Finally, we present the results of experiments (using texture projection merging and image processing assisted physical measurement) in which we have identified, characterized, and produced visualizations of selected fine surface detail from a digitization of Michelangelo's David statue.

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To Anna,

Beauty,

and Truth.

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