論文の内容の要旨

Extraction of coherent and smooth feature lines from meshes

（破線や揺れの少ない特徴線の抽出）

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This research intends to automatically extract feature lines from polygonal meshes. We aim to extract a set of coherent, smooth, scale-dependent lines that effectively capture and convey important shape features of a three-dimensional (3D) model.

Feature lines, especially ridge-valley lines, can be defined as the loci of points that maximize certain geometric properties (e.g. principal curvatures) along corresponding “critical directions” (e.g. the principal directions of curvatures). Such extrema over mesh edges are often determined by zero-crossings of directional derivatives [DeCarloetal2003] [Ohtakeetal2004] [Juddetal2007]. As a result, lines generated by existing algorithms frequently suffer from fragmentation (gaps in lines) and fluctuation (lack of smoothness). To fix this, we propose a novel method for tracing such lines [GaoYamaguchi2019]. Points on feature lines, that is, extrema over mesh edges, are detected and located by interpolating extrema in the vicinity of mesh vertices, which effectively reduces fragmentation and fluctuation of lines.

Meanwhile, we notice that certain surface regions, such as cylindrical, planar, and spherical regions, cannot be depicted effectively with “lines” because the geometric property, such as principal curvature, is not supposed to attain local extrema over such regions. On continuous surfaces, after excluding regions that do not correspond to feature lines, a single feature line can either be extracted from a region with positive area or from one with zero

area (e.g. a crease line). To ensure that users have control over the level of detail conveyed by feature lines, it is crucial to ensure that they can extract feature lines from even the "smallest" region. Therefore, we introduced the concept of "feature region," a connected region on a surface that can be classified into one of the following categories: no-line, large-scale (smooth), and small-scale (sharp). Our classification scheme employs our observation that a differential invariant (the curvature) and an integral invariant (the occlusion) behave slightly differently over different categories of feature regions. The result of classification ultimately depends on parameters whose values are decided by users, reflecting their perceptions of the significance of a specific feature region. We also propose a strategy of partial subdivision to separate multiple sharp feature regions that are topologically close to each other.

Our proposed method for scale-dependent feature-line extraction can distinguish smooth and sharp feature regions and render them accordingly while avoiding extracting undesirable lines from no-line feature regions. Our approach is especially useful for polygonal meshes generated by computer-aided design (CAD) but without original CAD files or low-resolution mesh data in general. Experimental results have demonstrated the effectiveness of our proposed methods for extracting coherent, smooth lines with a user-dependent level of detail.

References

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