Evaluating Hex-mesh Quality Metrics via Correlation Analysis

Issues of Datasets Generated with Available Software

Since there is no public hex-mesh dataset satisfying the above requirements, the most straightforward way of obtaining such datasets is to employ available hex-mesh generation libraries. We choose MeshGem for this experiment, which incorporates the octree-based hex-mesh generation method. The reasons of adopting an octree-based method for this experiment are: 1) it is one of the most robust and efficient techniques among currently available hex-meshing techniques; and 2) it is sensitive to the orientations of the input surface model, which can be utilized to serve our purpose of generating a large set of meshes for the same model. For instance, given the surface model of the crank, by slightly rotating it with a small angle (e.g., 5°) each time while keeping all the parameters fixed, we generate a dataset for it using MeshGem. Figure 1 (top) shows the distribution of the individual metric values for all hex-meshes (i.e., 657 in total) of the crank dataset using the parallel coordinate technique, where each curve represents a hex-mesh, and each vertical axis represents a metric listed in Table 1 of the paper. As shown in this visualization, the distribution of the metric values of these meshes is highly uneven. All the 657 samples can be clearly grouped into tens of clusters with distinct metric values. This means only tens of meshes in the crank dataset are usable for the correlation analysis. Compared to the 38 metrics, this is far from enough, not to mention that the number of elements and the connectivity of these meshes are not strictly the same. Furthermore, for many metrics, the sampled value range is rather small (e.g., the difference between the maximal and minimal values of S.JAC.Min is only 0.074). *Since there is no theoretical proof showing that the octree-based technique as well as other existing hex-meshing techniques will not generate hex-meshes with quality values falling in those unsampled ranges for a model, the above example indicates that hex-meshes generated with existing techniques may not provide sufficient samples of the metric space.*

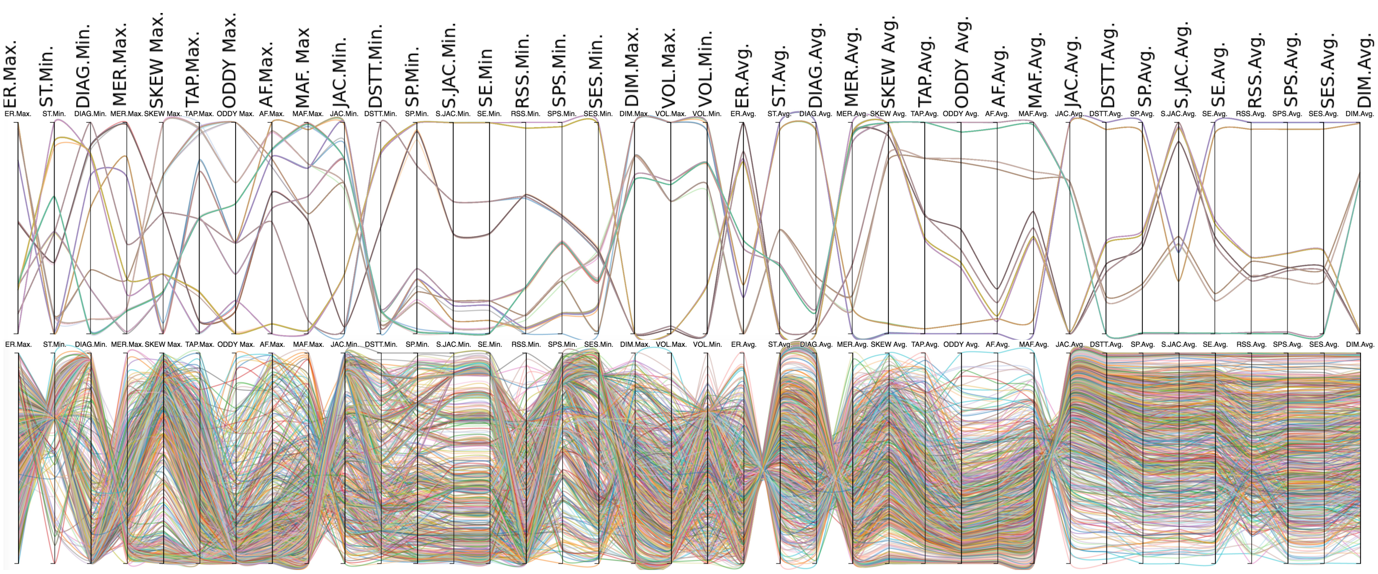

Fig. 1: Comparison of the parallel coordinate visualizations of all metric values of the crank hex-meshes (657 in total) generated using MeshGem (top) and those (818) obtained using the proposed noise insertion strategy (bottom). It is apparent that the hex-meshes generated using our approach have more even distribution in the metric space and cover larger ranges of values for those dimension and scale independent metrics, e.g., scaled Jacobian. Two colors are used for visualization purpose.