Paper Summary: CWF and GCNO

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The two papers both construct a ”good” object function (of something we want to change) to enforce the requirements, then use an optimization algorithm to get the optimal result.

1 CWF: Consolidating Weak Features in High-quality Mesh Simplification

1.1 Contribution

A novel **mesh simplification** algorithm satisfying these conditions which cannot be provided by former SOTA methods:

- Guarantee high-accuracy, high-quality and good feature alignment **simultaneously**
- Consolidate **weak feature** of the meshes (esp. organic models, which are different from CAD models)

, and an effective technique for RVD calculation on thin-plate models.

1.2 Method

Optimize an object function (of movable points) incorporating both NA, which facilitates **feature alignment**, and CVT energy, which achieve an even distribution of movable points, that is, **high-quality** mesh.

Based on the observation that the NA and CVT energy change at different rate, leading to a unbalanced state, this paper introduces a **decaying weight** for CVT term, resulting in a process that produces high-quaily mesh first and then regularizes feature alignment gradually.

2 Globally Consistent Normal Orientation for Point Clouds by Regularizing the Winding-Number Field

2.1 Contribution

A novel algorithm computing a **globally consistent normal field for point clouds**. It is robust even for inputs with nearby gaps or thin-walled structures.

It is based on three key observations:

1. If the point cloud is equipped with a meaningful normal setting, the winding number can robustly distinguish the inside from the outside in a global manner and is valued at 1 (inside) and 0 (outside).

2. If the point density meets the local feature size standard, one half of the Voronoi cell dominated by one point is located inside the surface, and the other half is located outside.

3. Voronoi poles are useful for orienting the normals.

Transform them into our requirements (constraints):

1. The winding number is either 0 or 1.

2. the occurrences of 1 and of 0 are balanced around the point cloud.

3. the normals align with the outside Voronoi poles as much as possible.

2.2 Method

Optimize an object function (of normals) incorporating three terms, corresponding to the three requirements aforementioned (in my view this is like transforming a constrained optimization problem into an unconstrained optimization problem?):

1. **The 0-1 Term** Use double well function for the first requirement. To make the normal field "move" rather than "stay" starting with random normals (in which case most winding numbers are 0, then of course the double well function is already near 0), this paper augments the double well function with a shear correction (lower energy if the winding number approaches into 1 than if it approaches 0).

2. **The Balance Term** Variance of winding numbers.
3. **The Alignment Term** To get the consistent directions, the two sequences should have reverse ordering: (1) the winding number of the Voronoi cell vertex (2) the dot product of normal vector and the vector pointing from each point to its each Voronoi cell vertex.

2.3 A parameter-free strategy to compute the area weight of each point

Instead of KNN, which is parameter-dependent, this algorithm adopts a different strategy:

1. Calculate the vector pointing from the point to its (max) Voronoi pole
2. Construct a plane taking this vector as its normal
3. Intersect the plane with the Voronoi cell
4. area weight := area of this cut polygon