Anisotropic layering via curve insertion into unstructured meshes

Daniel W. Zaide and Carl F. Ollivier-Gooch

University of British Columbia

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Introduction

Problem: take a pre-existing mesh and insert a series of prescribed internal boundaries into its topology.

Goal: obtain internal boundaries in a general, pre-existing mesh with minimal mesh modification, connected by anisotropic elements.

Motivation: remeshing to match the surfaces of a newly deposited layers of material in the simulation of the semiconductor device manufacturing process.

Review

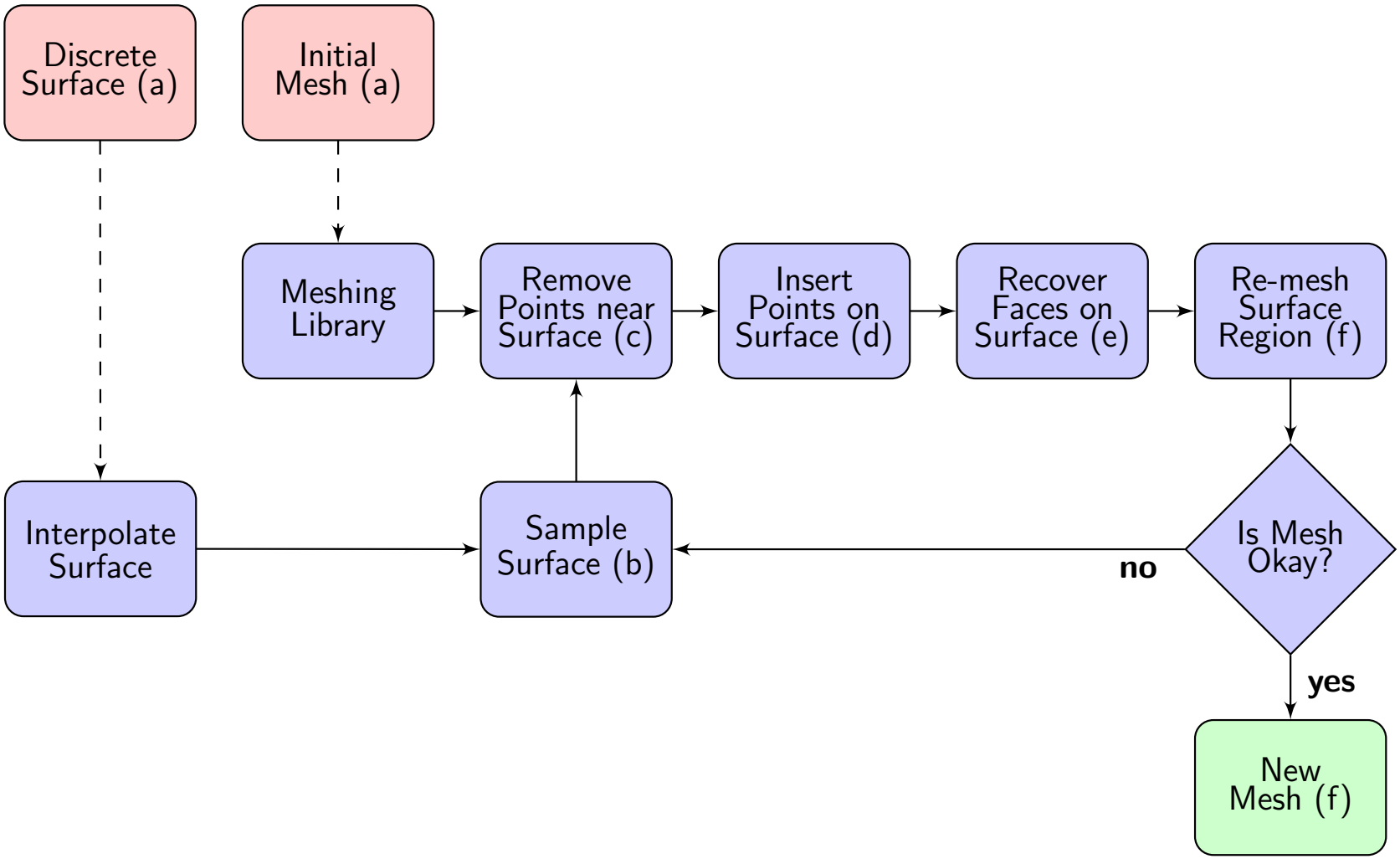
Previous work demonstrated initial curve insertion algorithm in 2D (IMR2013) and 3D (submitted).

There are several other local approaches that use projection and mesh movement (eg. cleaving).

Our approach is to insert and remove points with local operations to recover the surface and post process to recover quality.

This allows for insertion of arbitrary geometries, with minimal requirements on geometric smoothness and on topology or quality of the existing mesh.

Curve/Surface Insertion Algorithm Overview



Curve Spacing

To determine curve (or surface) point spacing, we use a length scale on the existing mesh using a vertex length scale and barycentric interpolation.

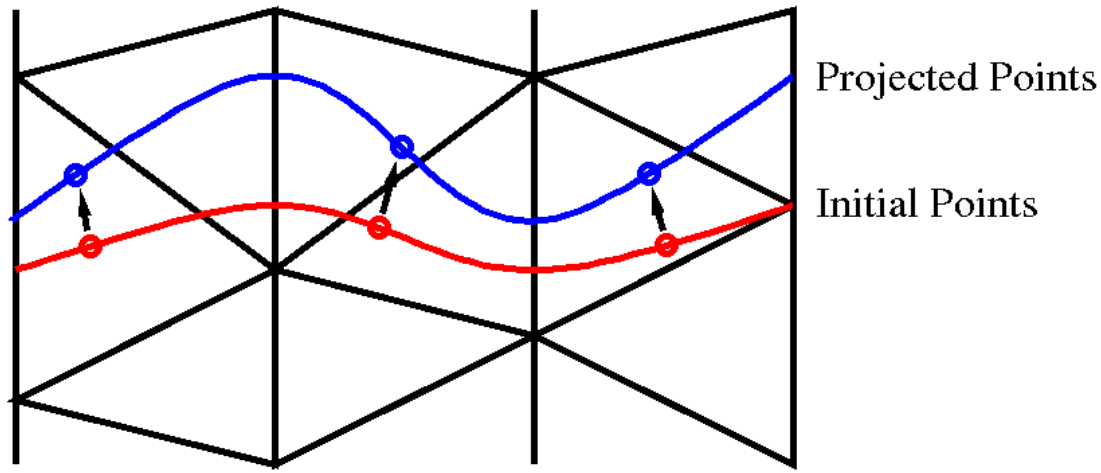
$$LS(v) = \left(2 \sum_{i=1}^{N} A_i \Big/ \sum_{i=1}^{N} \theta_i \right)^{\frac{1}{2}}$$

We then march along the curve placing points using the length scale, and then equistribute (smooth) point locations to get a curve sampling sized similar to the existing mesh.

Easily extended to anistropic meshes ('rejected' research note) with metric-based length scale.

Anisotropic Layering

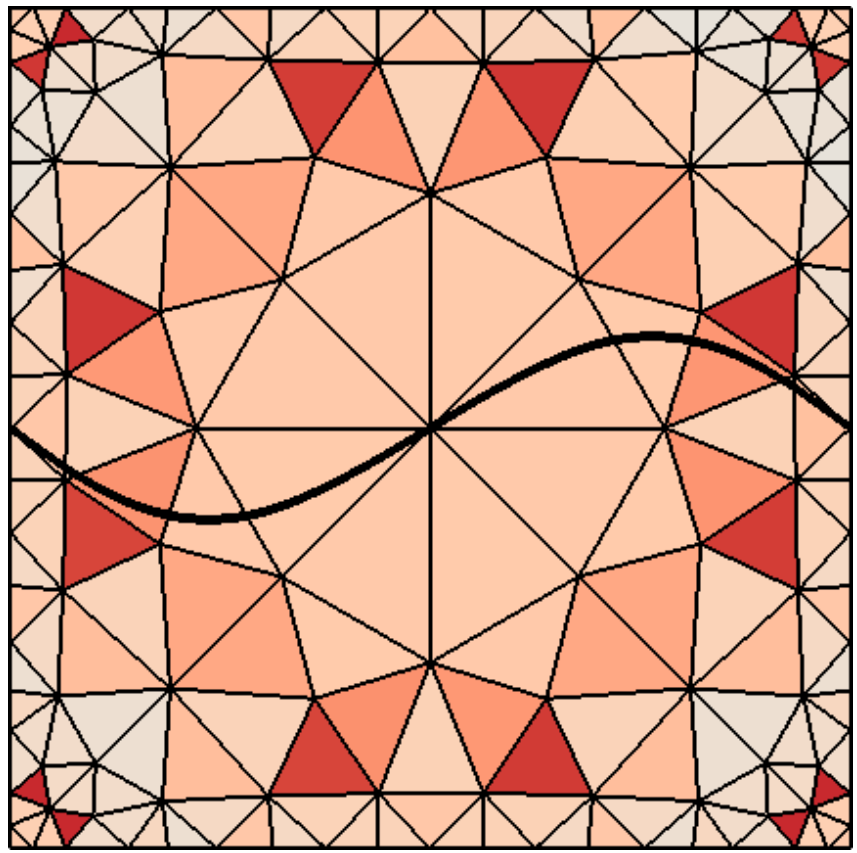
With an initial curve sampled, sampling on adjacent curves is achieved by projecting insertion points normal (smoothed normal) on to the new curve, inserting, and forming anisotropic elements.



After final sampling, points are inserted and post processing (swapping, smoothing, refining) used to recover quality.

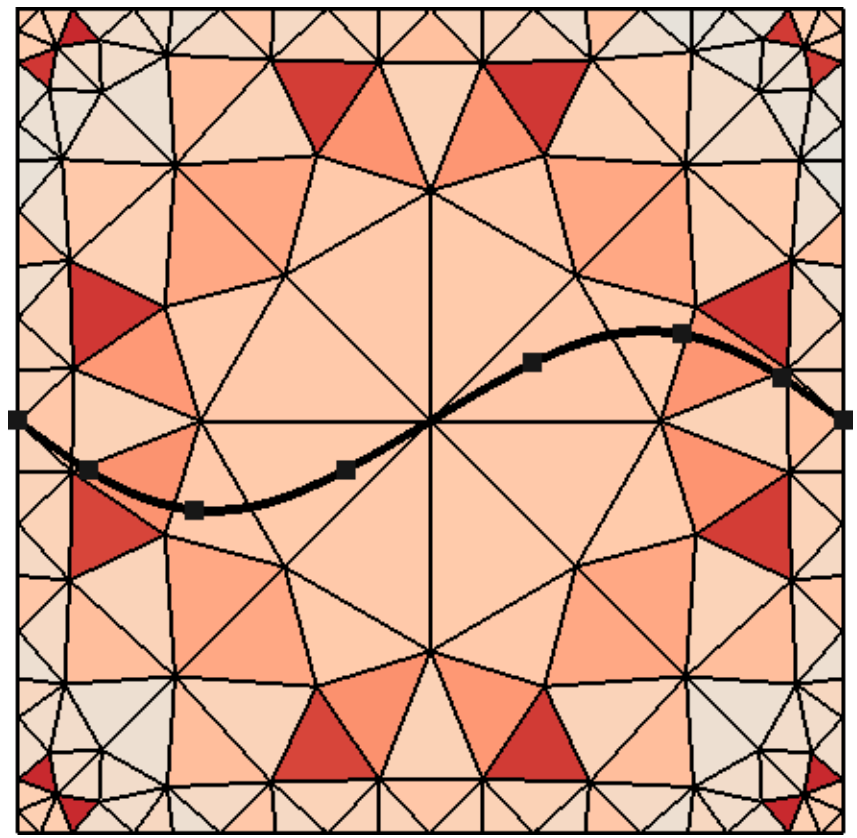
Results

Example 1 - Initial Mesh



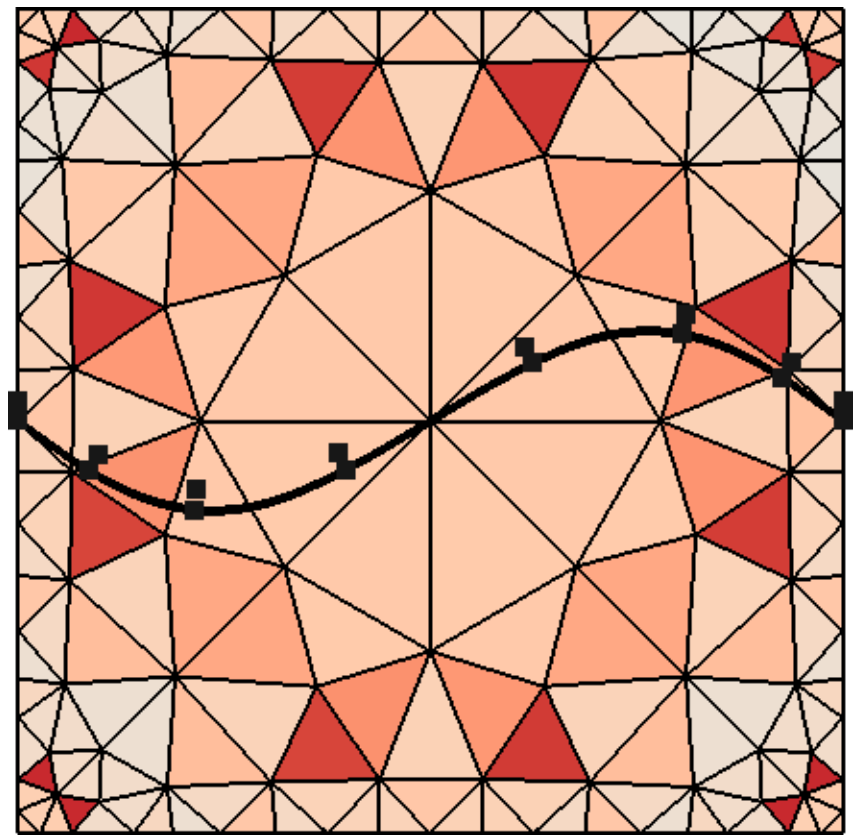
Results

Example 1 - Curve Sampling



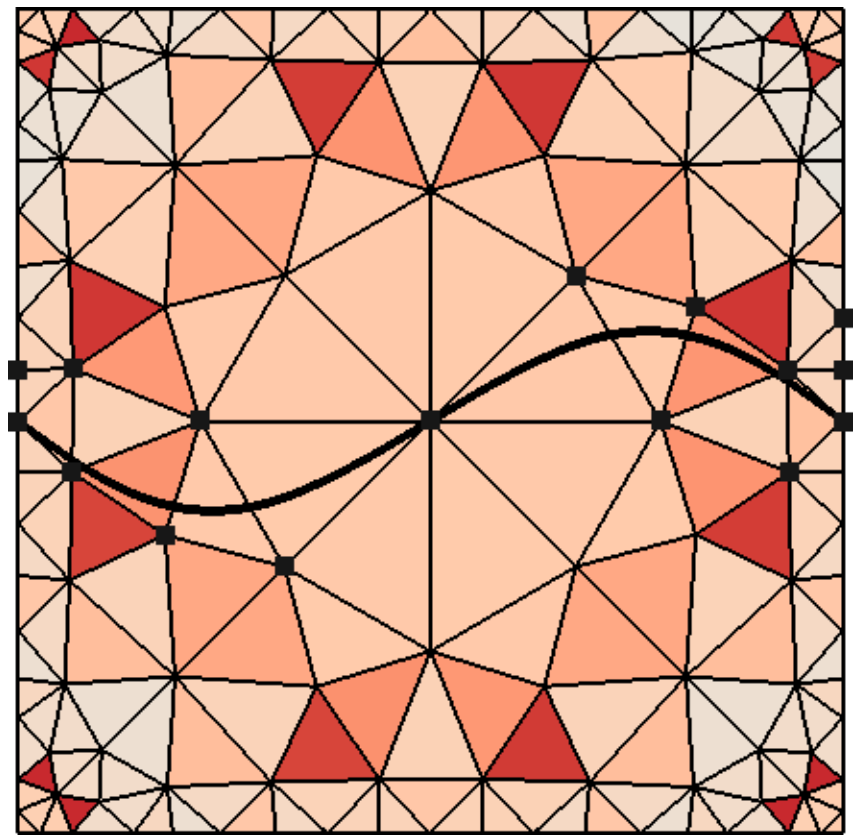
Results

Example 1 - Point Projection



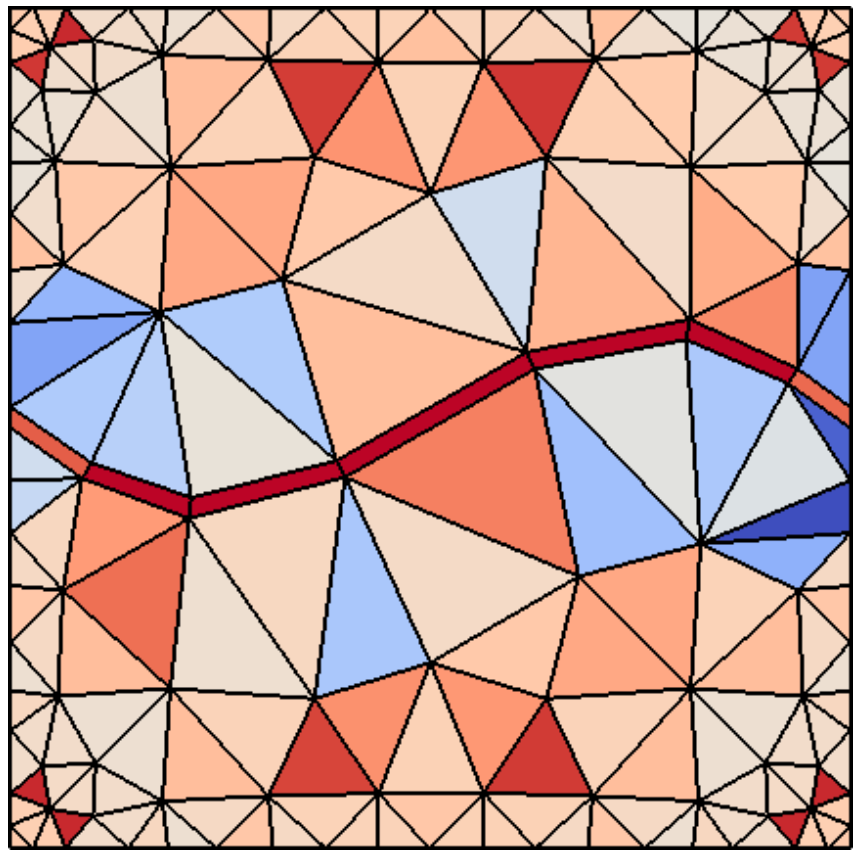
Results

Example 1 - Mesh Clearing



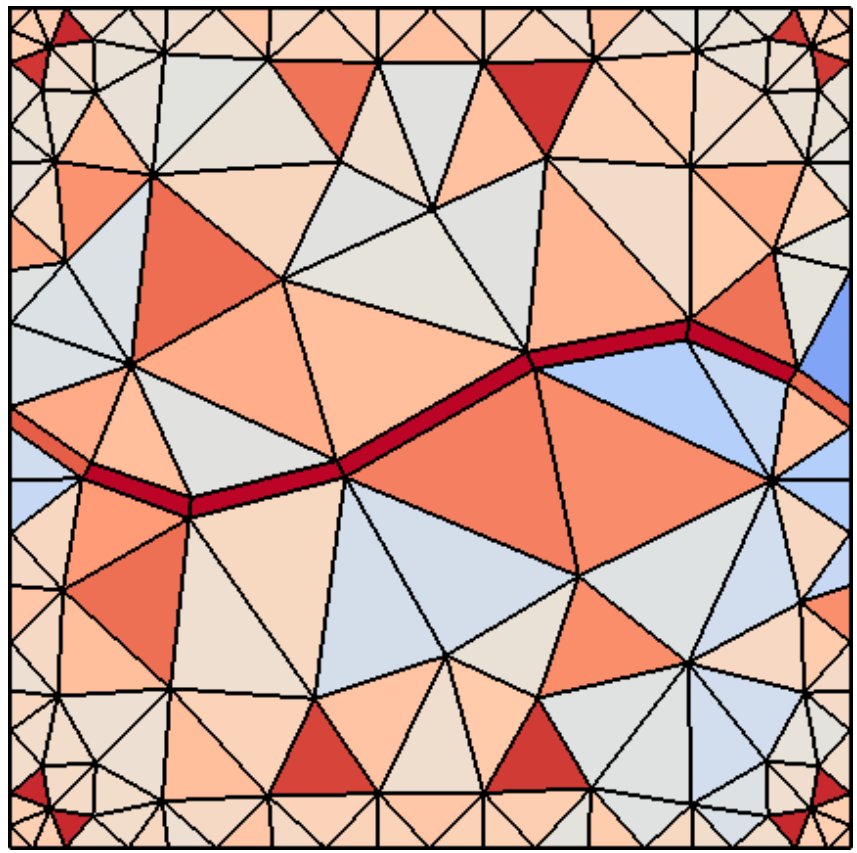
Results

Example 1 - Point Insertion



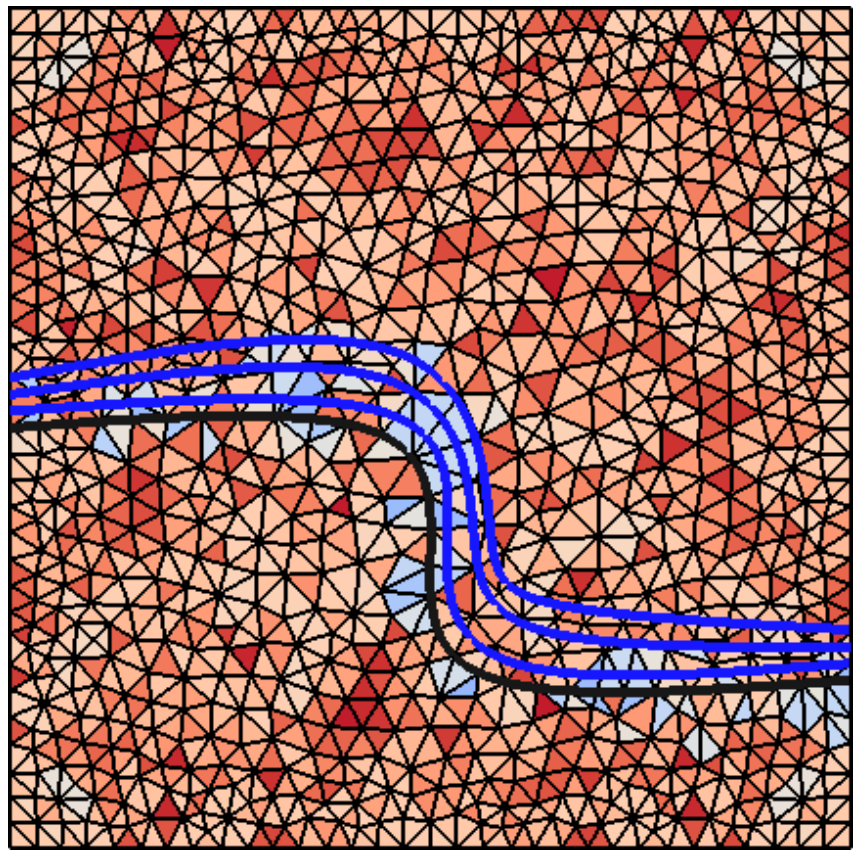
Results

Example 1 - Final Mesh



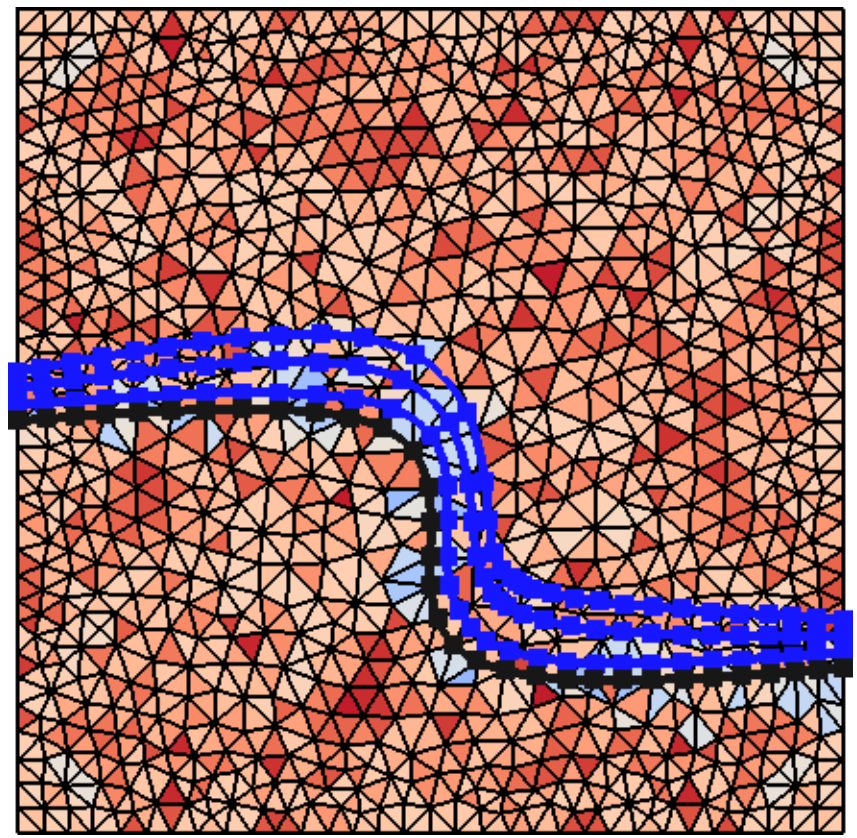
Results

Example 2 - Initial



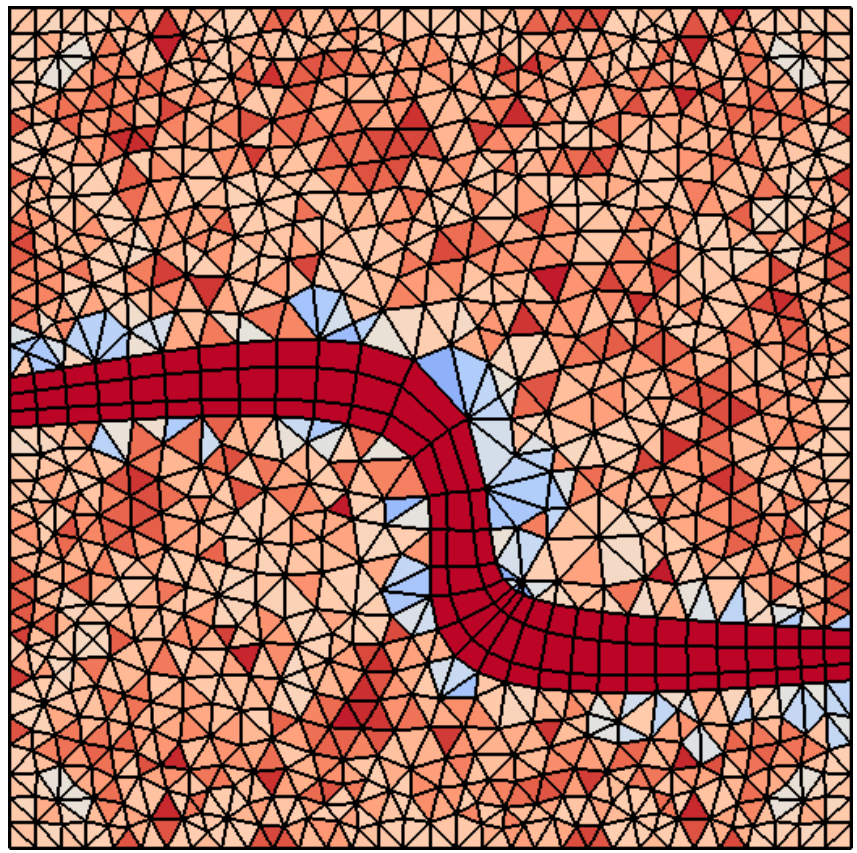
Results

Example 2 - Point Locations



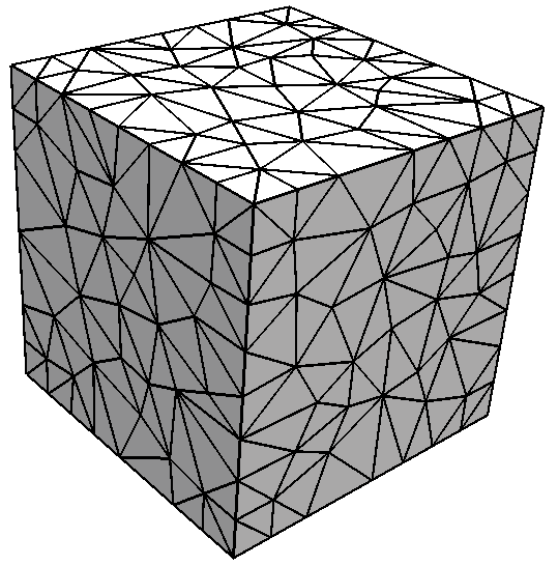
Results

Example 2 - Final Mesh



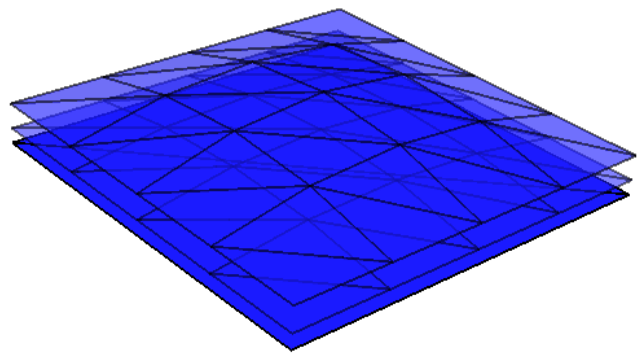
Results

Example 3 - Initial



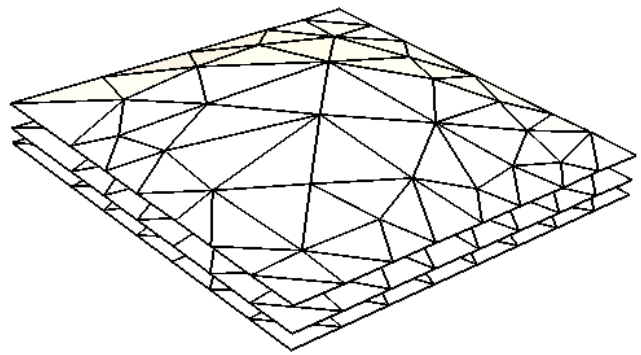
Results

Example 3 - Surfaces



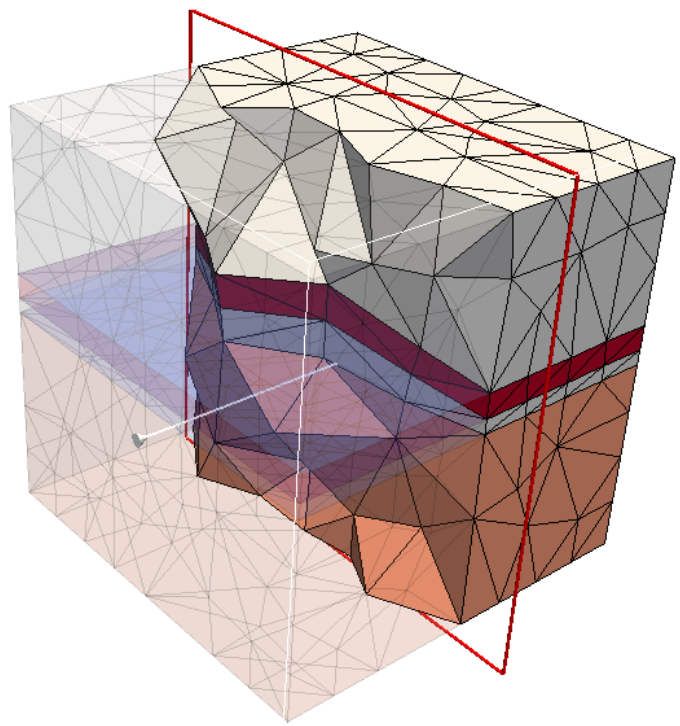
Results

Example 3 - Sampling



Results

Example 3 - Final



Conclusions

We have developed and implemented an algorithm for anistropic layer creation in an existing mesh based on our previous work on curve insertion.

Future work will focus on improving the 3D implementation and preserving structure when inserting into quasi-structured meshes.

Questions?