Semantic Overlap Free Layouts of Surface Paramaterizations

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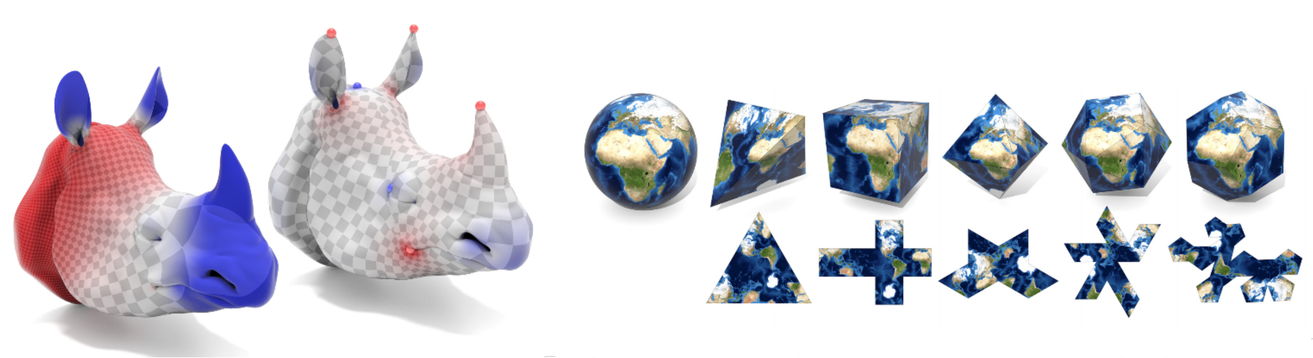
Abstract

Computing UV parameterization is a fundamental task in geometry processing with applications in texturing, machine learning and 3D fabrication. In general, the goal is to take a surface and map it to a plane while minimizing the distortion. A recent approach that drastically reduces distortion in parameterization uses the method of cone singularities. Rather than mapping the surface directly to a plane, we can find an intermediate polyhedron that better approximates the surface. Afterwards, the polyhedron can be laid out in the plane by cutting through a spanning tree that passes through the taken cones. However, this pipeline does not guarantee a layout that does not overlap itself. Tackling this problem of layout does not need to take distortion into account, since the shapes have already been flattened. We explore ways to partition the layout so that it is free of overlaps and the separated components are few and semantically reasonable.



Figures taken from the paper, Optimal Cone Singularities for Conformal Flattening

Motivation

As a result of overlaps, two or more parts of a texture map can access colors from the same part of an image - which is undesirable.

Cognitive science proposes that the human visual system perceives region boundaries along concave creases on a surface.

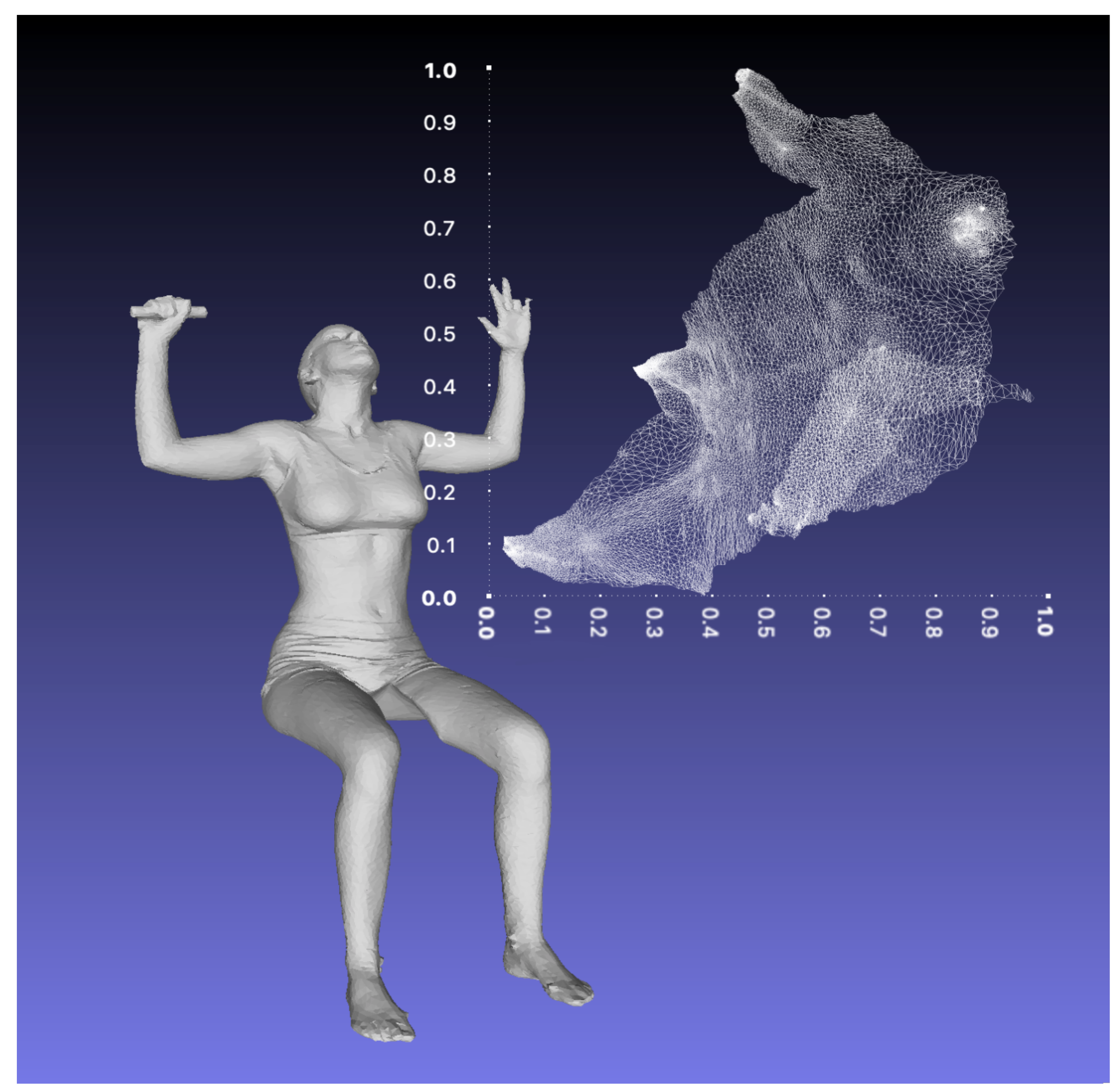
Users prefer flattenings that they can associate with segmented pieces of the original surface.

Approach

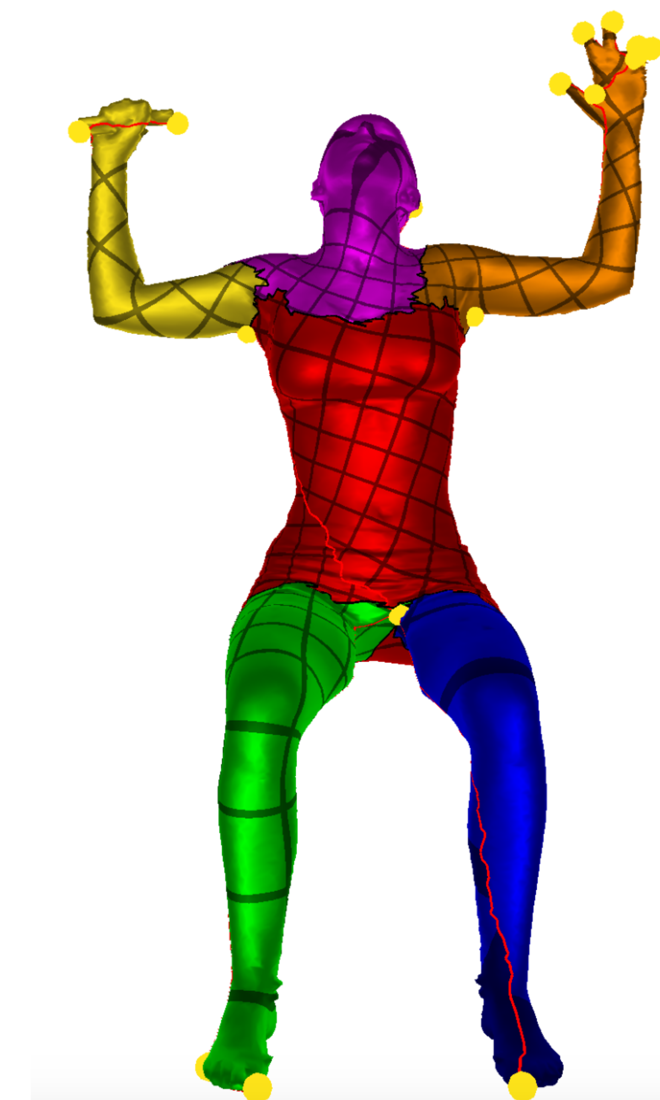
In the case of a paramaterization that contains overlaps, we take the surface and segment it into meaningful components. Then, with the intrinsic triangulation these pieces can each separately be layed out again with no change to the distortion

Method

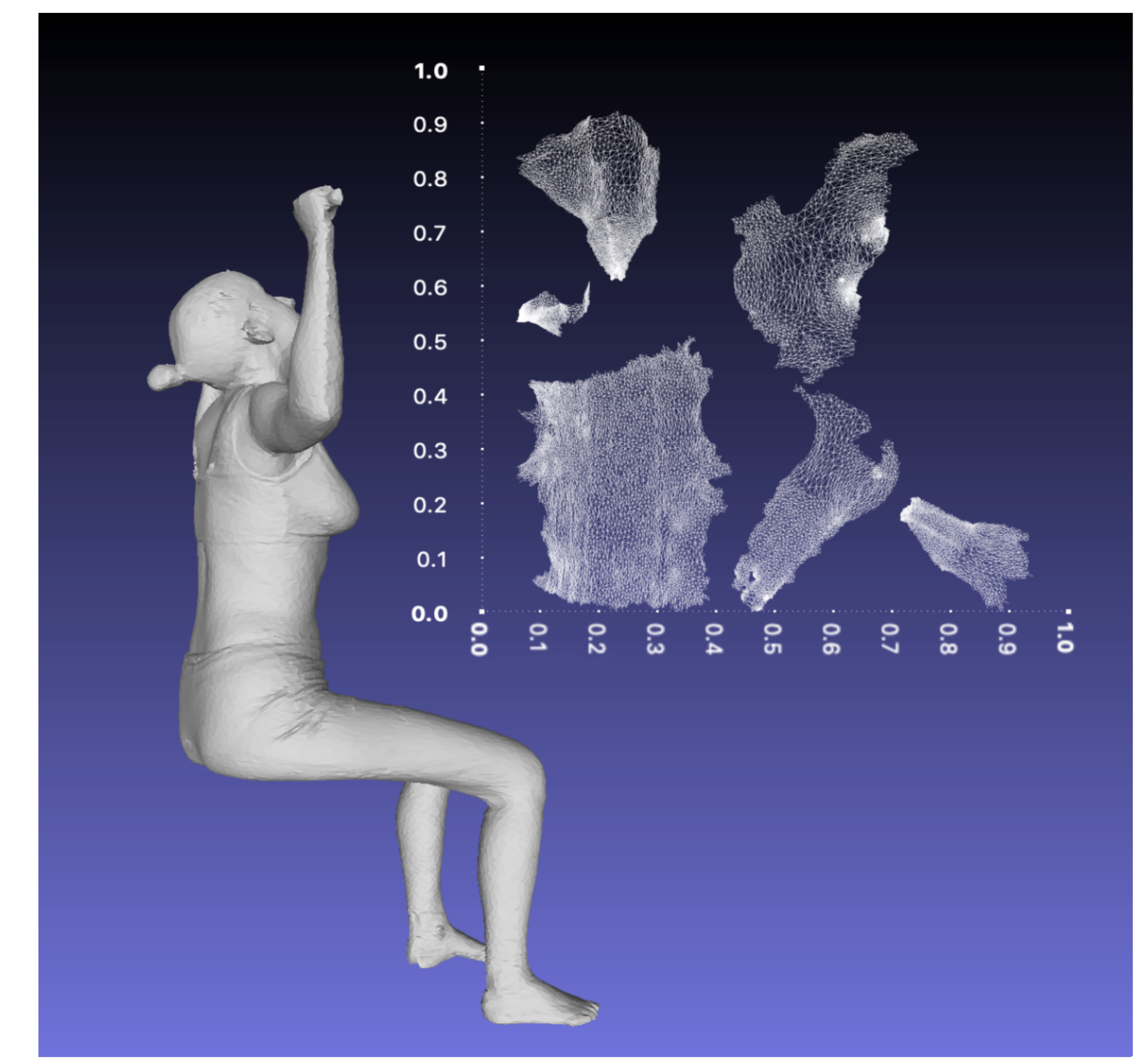
From the flattening an intrinsic triangulation is produced, meaning that we do not know how the polyhedron is embedded in space but know the edge lengths of the triangulation. As a result, when there are overlaps, the faces can be shifted around until some non-overlapping solution can be found.



Step 1: Use Boundary First Flattening (BFF) to flatten the surface to the plane. This introduces a flattening that greatly reduces distortion but may introduce overlaps on the plane.



Step 2: Use segmentation techniques such as K-Means and, with additional considerations of curvature, segment the mesh into "nice" visual components.



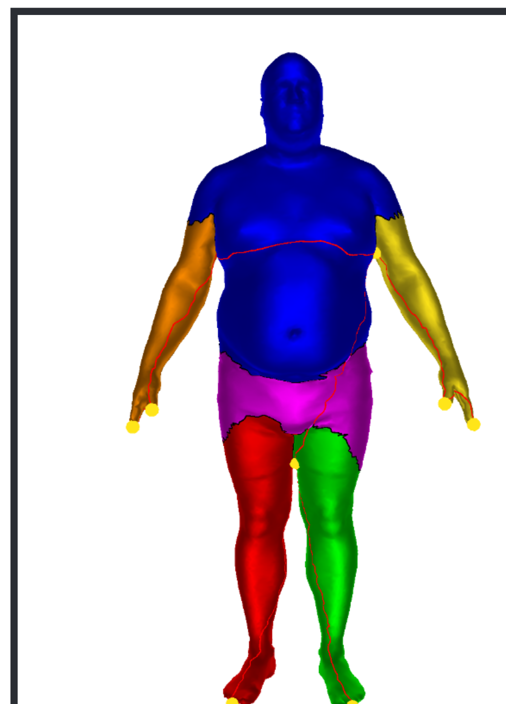
Step 3: Using the fixed edge lengths of all faces in the plane, each segment can once again be layed out face by face. Faces that previously overlapped are now in separate, laid pieces.

Observations and Future Work

Though the chances are reduced in practice, layed segmented pieces may still have overlap.

In the end, with mesh's segmentation there is hardly a right or wrong answer, as its quality is judged by different individual's preferences. Removing overlaps is, however, a must and this method has some promise.

Additional considerations could be made about combining semantic segmentation with knowledge of the spanning tree of cuts made between the cone singularities for BFF. This could greatly reduce or eliminate creation of overlaps while also preserving meaning.



References

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