CS 749 DIGITAL GEOMETRY PROCESSING

Shape Segmentation and Retrieval using Global Point Signatures.

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Team Members:

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Introduction:

Our problem definition is to implement the local descriptor GPS for surfaces as described in the paper "Laplace-Beltrami Eigenfunctions for Deformation Invariant Shape Representation" by Raif M. Rustamov. The paper has described a new framework to represent non-rigid shapes. Our main goal is to implement the GPS embedding as a means of ripping a surface from its "transient", Euclidean embedding related properties, to keep its essence – features that are isometry invariant. Using the GPS descriptor we intend to perform shape segmentation and retrieval on non-degenerate closed 3D manifold meshes.

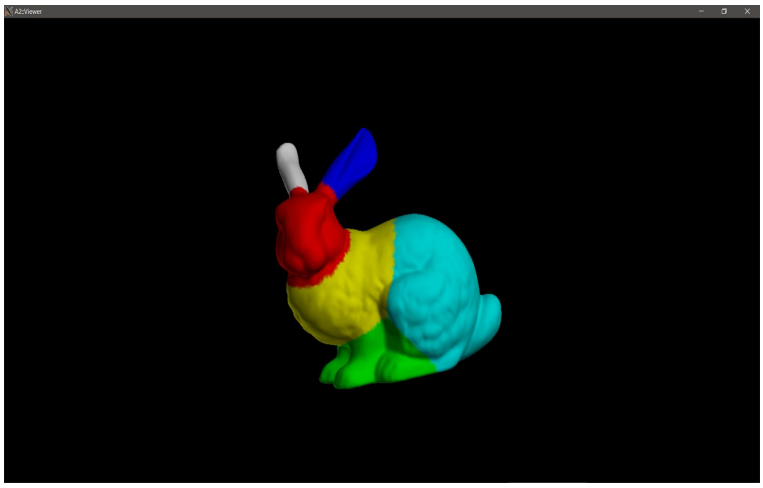
Implementation:

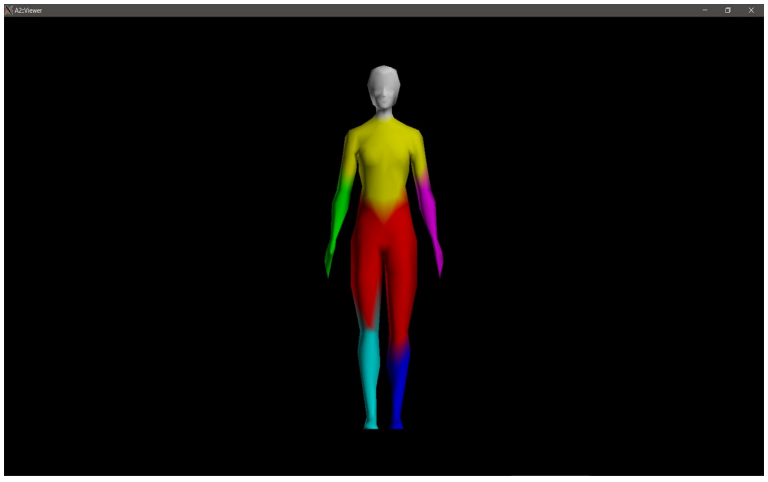
We almost exclusively followed the paper to construct the discrete Laplacian matrix whose eigenfunctions are to be found for GPS. We had few problems regarding the normalisation of the cotan weights over the star of each vertex. For thin simplices in the mesh, the paper Xu [Xu06](used in the above paper) suggested a Delaunay flip in order to avoid negative values of normalisation constants. In order to reduce the complication and at the same time get decent results, we followed the normalisation as stated in Meyer et al. [MDSB02]. Briefly stating the normalisation component for each neighbor of a vertex is taken as the sum of the signed areas of the two triangles formed by the vertex, the midpoint of the vertex and neighbour and the circumcenter of the face containing this edge. This can be

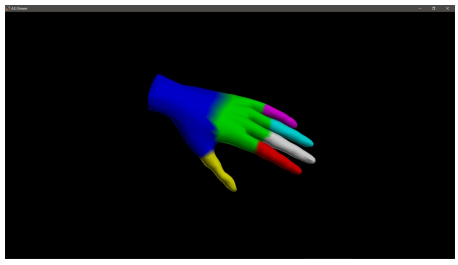
negative when the faces are obtuse. In that case Xu06 suggests a Delaunay flip whereas MDSB02 suggests taking 0 area for that neighbor.

We found M and S (refer to paper) in a sparse way using the library Eigen and used the Generalized Eigen Solver from the library Spectra based on ARPACK and Eigen. Also the number of eigenvalues used to compute GPS is desired to be less than half the number of vertices for faster computation. This can be changed by changing the ncv parameter of the Eigen Solver.

We implemented k-means clustering in GPS space to perform shape segmentation. Initialisation was random. Some of the results are:

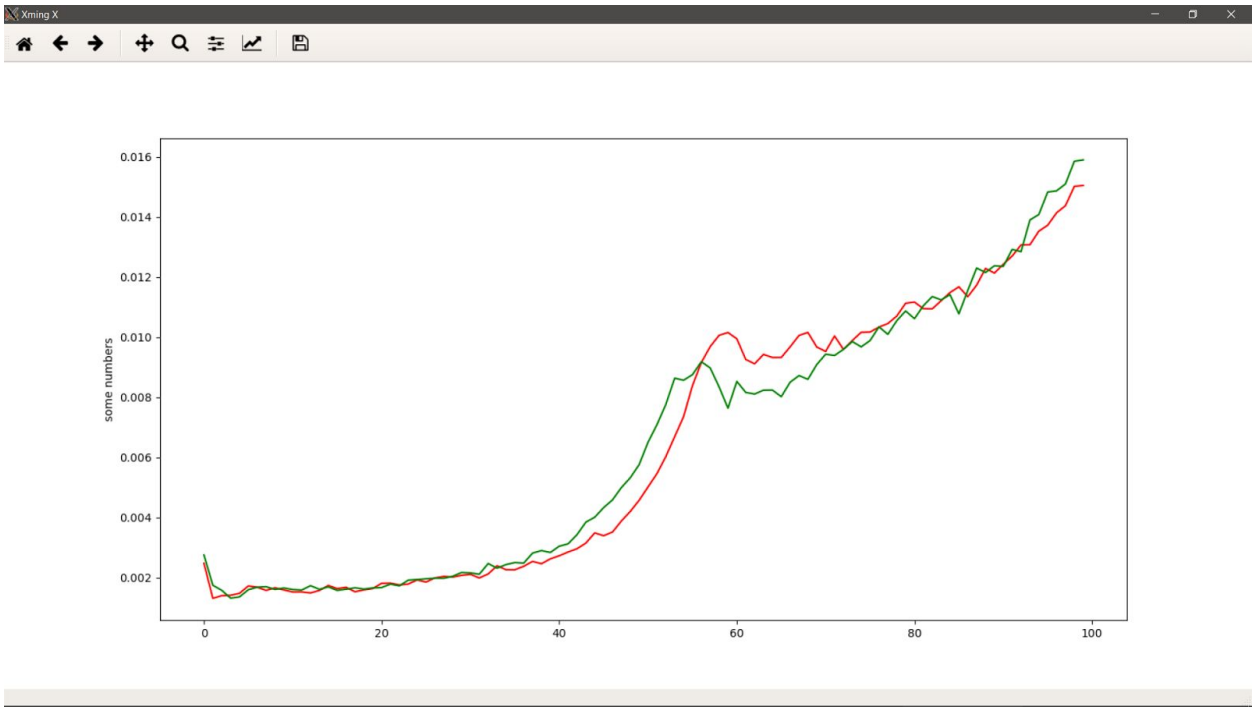






Using the GPS space, we also formed a global descriptor of shape by forming a D2 descriptor for pairs of m spherical shells in GPS space. This can be used for shape classification and retrieval. We plotted some results with m=1:

Left hand and Right hand(Not completely identical even after flip):



Contribution:

Implementation of the discrete Laplacian and solving for the eigenvalues: Uday and NIhal

Global Descriptor using GPS: Krishna Chaitanya

K-means clustering in GPS space and segmentation: Suraj and Uday