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Systems and Methods for Medical Imaging Shape Measurements

There has been much research into developing learning methods on non-Euclidean domains such as point clouds, various meshes and graphs. However, very few have studied CNNs on tetrahedral meshes, which are highly useful in medical imaging applications. Tetrahedral meshes have millions of edges and vertices and existing graph convolutional networks are not able to scale to these large sample sizes. While there are some CNNs for triangular meshes, they are not designed for the high number of vertices seen in tetrahedral meshes.

Researchers at Arizona State University have developed a novel interpretable graph CNN framework for the tetrahedral mesh structure, called TetCNN. In this framework, the volumetric Laplace-Beltrami Operator (LBO) of each tetrahedral mesh is precomputed, then together with the LBO, a set of input features for each vertex is fed into the network. Next, the mesh is down-sampled with an efficient pooling layer to learn hierarchical feature representation for the large-sized input data. This essentially uses volumetric LBO to replace graph Laplacian used in ChebyNet.

This framework has an edge compared to surface mesh and point-cloud representation in that it makes data representation of structural thickness and internal values more informative.

Potential Applications

- Medical image analyses
  - Brain imaging (brain cortical/cranial ribbon)
  - Knee cartilage thickness analyses
- Supervised learning tasks including classification, regression and segmentation
- Could be used to identify imaging biomarkers
- Simulation and solid animation

- Object detection or part segmentation
- Novel generative models to create tetrahedral meshes

Benefits and Advantages

- More computationally efficient
- Applicable to volumetric meshes for different tasks without the need for equal-size input mesh
- Can handle different input sizes by approximating LBO on each mesh in deeper layers after down-sampling
- LBO successfully characterizes the difference between two mesh structures while the graph Laplacian fails
- Better able to visualize details and boundaries in medical imaging
- Better able to capture regions of interest for group-level studies

For more information about this opportunity, please see

Farazi et al – Conference Paper – Information Processing in Medical Imaging - 2023

For more information about the inventor(s) and their research, please see

Dr. Wang's departmental webpage