PointSet & Mesh

BM4302 - Medical Image Processing

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Data Representation

basic classes responsible for representing data in ITK

- itk Image
- itk PointSet
- itk Mesh

PointSet

- PointSet is a basic class in ITK for representing sets of points in N-dimensional space
- Serves as the base class for itk::Mesh
- Allows for manipulation of points within a defined space
- The point data includes a point ID
- Static vs. Dynamic Interaction Styles

Templated parameters

PixelType :

specifies the type of value associated with each point in the point set. any data type, such as float, double, unsigned int, etc.

Dimension :

determines whether the points are in 1D, 2D, 3D, or higher dimensions.

Create Pointset

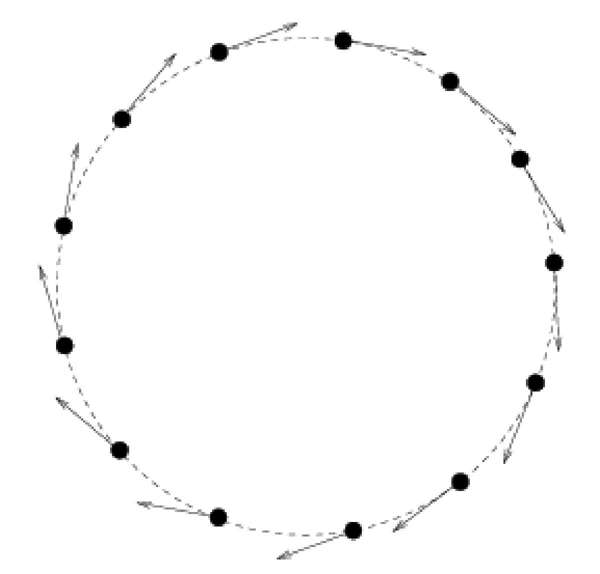
Pixel Type

Scalar Types:
float, double for grayscale intensity

RGB Types:
itk::RGBPixel<float> for color representation

Vector Types:
itk::Vector<float, 3> for multi-dimensional data (e.g., gradients, displacements)

Normal Types:
itk::CovariantVector<float, 3> for surface normals



Vectors as Pixel Type

Usage of PointSet

Landmark-based Image Registration:

- Aligning images from different modalities (e.g., CT and MRI) or time points using anatomical landmarks.

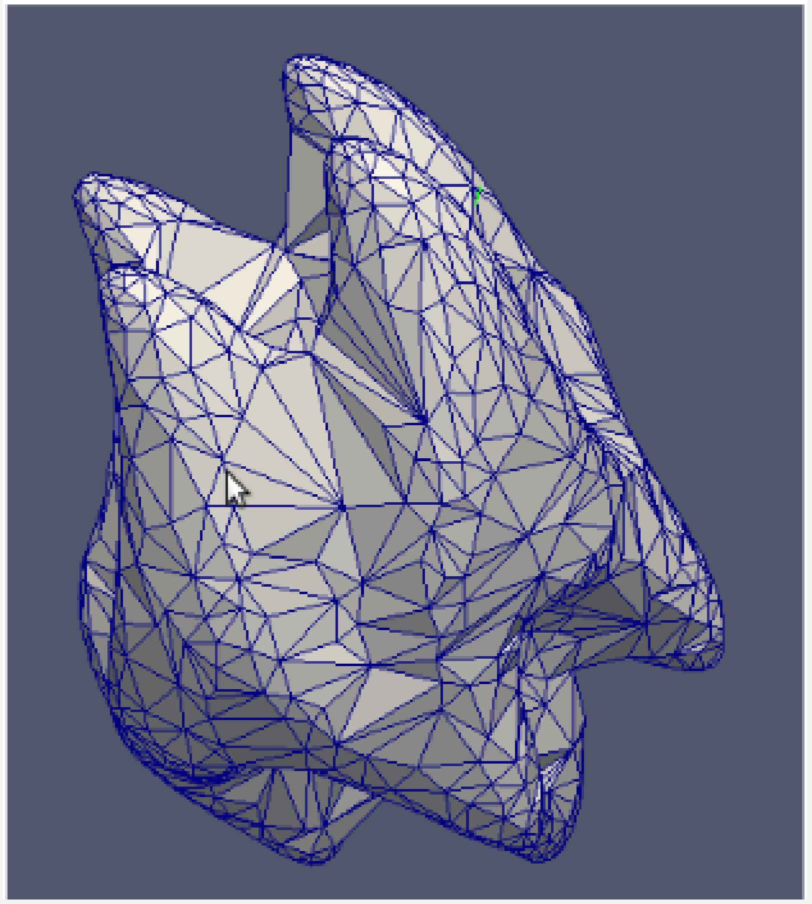
Sparse Representation of Structures:

- Application: Representing anatomical structures using a sparse set of points, such as the boundary points of a vessel or the outline of a tumor.

3D Image Feature Extraction:

- Application: Extracting and analyzing specific features from 3D medical images, such as the tips of vessels or specific anatomical landmarks.

Mesh



- itk::Mesh is designed to represent shapes in space, extending the functionality of itk::PointSet
- Supports N-dimensional representations, making it highly flexible.
- Points & Cells: Inherits points from PointSet and adds cells (elements) that define shapes using point-identifiers.
- Static Vs. Dynamic Mesh

source :

Cell Types

- itk::VertexCell
- itk::LineCell
- itk::TriangleCell
- itk::QuadrilateralCell
- itk::TetrahedronCell
- itk::PolygonCell

Template Parameters of itk::Mesh

PixelType. The value type associated with every point.

PointDimension. The dimension of the space in which the mesh is embedded.

MaxTopologicalDimension. The highest dimension of the mesh cells.

CoordRepType. The type used to represent spacial coordinates.

InterpolationWeightType. The type used to represent interpolation weights.

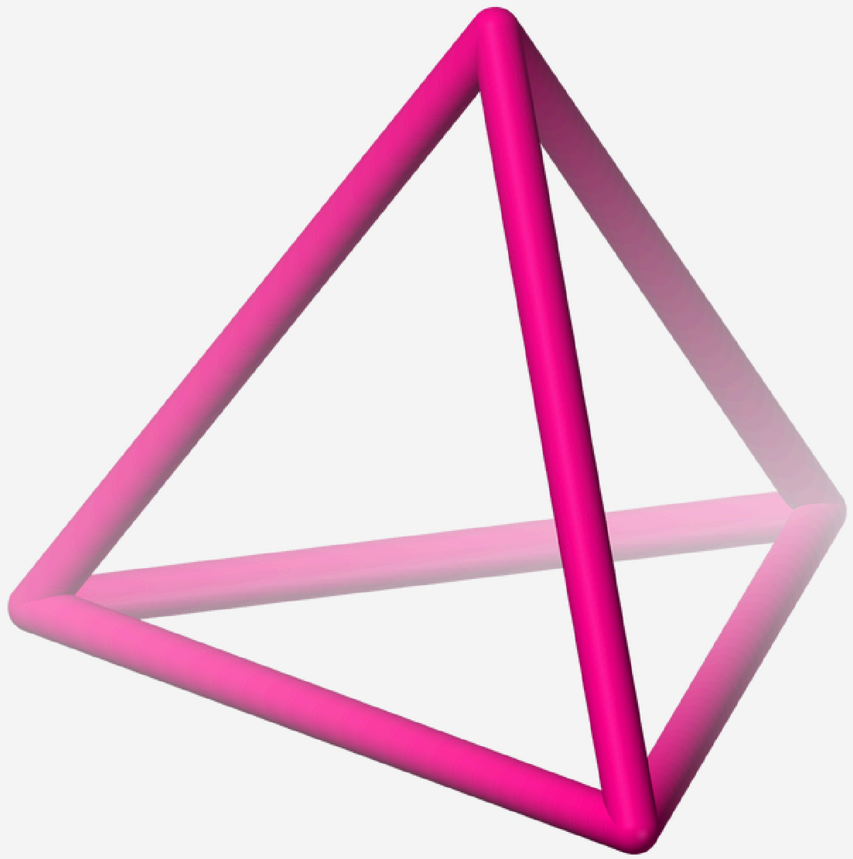
CellPixelType. The value type associated with every cell.

```cpp
constexpr unsigned int PointDimension = 3;
constexpr unsigned int MaxTopologicalDimension = 2;

using PixelType = itk::Vector<double, 4>;
using CellDataType = itk::Matrix<double, 4, 3>;

using CoordinateType = double;
using InterpolationWeightType = double;

using MeshTraits = itk::DefaultStaticMeshTraits<PixelType,
                                                PointDimension,
                                                MaxTopologicalDimension,
                                                CoordinateType,
                                                InterpolationWeightType,
                                                CellDataType>;

using MeshType = itk::Mesh<PixelType, PointDimension, MeshTraits>;
```

Topology and the K-Complex

A K-Complex is a topological structure where each cell of dimension N has its boundary faces (cells of dimension N−1) included in the structure.

Example: Composed of a tetrahedron, four triangle faces, six edges, and four vertices.



Add points and edges

Usage of Mesh

Surface Reconstruction:

- Generating 3D surfaces from segmented medical images, such as converting a segmented tumor into a 3D mesh for visualization and analysis.

Finite Element Analysis (FEA):

- Used in biomechanical modeling, such as simulating the mechanical properties of bones or tissues.

Surgical Simulation:

- Creating interactive models for surgical planning or training, such as simulating a cutting operation on an organ.

Tissue Deformation Modeling:

- Modeling the deformation of soft tissues during surgical procedures.

Thank You