The Filtered Tangent Complex: A Mathematical Approach to Categorizing Shapes

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One method to mathematically categorize shapes is to apply persistent homology to the filtered tangent complex. We analyze point cloud data (PCD) by first considering the tangent complex: the set of ordered pairs which include the base point found in the PCD along with the unit tangent vector. By filtering this tangent complex by curvature, we are able to take advantage of the differentiating power of geometry. Curvature is a measure of how much a geometric object strays from being straight; it is equal to the reciprocal of the radius of the unique osculating circle. We add the epsilon-ball centered at each of the PCD basepoints at the time equal to the value of the curvature, so we can analyze how this shape changes over time. Analysis is done by utilizing persistent homology, a method which looks at how the topological features changes with time. Persistent homology employs the idea that more persistent features (features that are present for a longer time) represent true topological features rather than noise.

The k-dimensional Betti number is equal to the number of k-dimensional holes and can be used to distinguish topological spaces and give a very coarse characterization of the space in question. We visually represent these betti numbers in barcodes, which can then be compared, matched and classified using any number of techniques to categorize the shape. Our method may be applied to simple shapes in order to solve it quickly and accurately.