Abstract of "Three-Dimensional Shape Representation via Shock Flows,"
by Frederic Fol-Leymarie, Ph.D., Brown University, May 2003.

We address the problem of representing 3D shapes when partial and unorganized data is obtained as an input, such as clouds of point samples on the surface of a face, statue, solid, *etc.*, of regular or arbitrary complexity (free-form), as is commonly produced by photogrammetry, laser scanners, computerized tomography, and so on. Our starting point is the medial axis ($\mathcal{MA}$) representation which has been explored mainly for 2D problems since the 1960's in pattern recognition and image analysis. The $\mathcal{MA}$ makes explicit certain symmetries of an object, corresponding to the shocks of waves initiated at the input samples, but is itself difficult to directly use for recognition tasks and applications. Based on previous work on the 2D problem, we propose a new representation in 3D which is derived from the $\mathcal{MA}$, producing a graph we call the *shock scaffold*. The nodes of this graph are defined to be certain singularities of the shock flows along the $\mathcal{MA}$. This graph can represent exactly the $\mathcal{MA}$ — and the original inputs — or approximate it, leading to a hierarchical description of shapes.

We develop accurate and efficient algorithms to compute for 3D unorganized clouds of points the shock scaffold, and thus the $\mathcal{MA}$, as well as its close cousin the Voronoi diagram. One computational method relies on clustering and visibility constraints, while the other simulates wavefront propagation on a 3D grid. We then propose a method of splitting the shock scaffold in two subgraphs, one of which is related to the (*a priori* unknown) surface of the object under scrutiny. This allows us to simplify the shock scaffold making more explicit coarse scale object symmetries, while at the same time providing an original method for the surface interpolation of complex datasets. In the last part of this thesis, we address extensions of the shock scaffold by studying the case where the inputs are given as collections of unorganized polygons.