Visualisation of Extremum Graphs

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Abstract

Every dynamic system we encounter in daily life is time varying in nature. Some examples of such time varying phenomena include Network Analysis, Weather forecasting, Engineering Fluid Dynamics. These phenomena can be analysed using temporally ordered sequence of graphs. These graphs are useful in encoding the state of the phenomenon at each time step. Typically, these graphs encode the spatial distribution of critical points of the underlying scalar field that represents such phenomena. In Scientific visualization these critical points are important to analyse the system. Designing this graph effectively and efficiently so as to capture the spatiotemporal variation of underlying topology is a tough task. In this context, Topological Spines—a new visual representation that preserves the topological and geometric structure of a scalar field, is useful. This representation encodes the spatial relationships of the extrema of a scalar field using a graphical structure, known as extremum graph, together with the local volume and nesting structure of the contours surrounding the extrema. Our main objective is to visualise the time varying topological aspects using **Extremum Graphs** of various datasets in Paraview software. Extremum Graph describes the connectivity of the spine and preserves the relative location of extrema within a neighbourhood using the so-called gradient lines connecting them. Unlike other representation, such as Morse-Smale complex that is far too complex to provide a meaningful visualization, extremum graph which is a subset of Morse-Smale complex, allows us to interactively explore structures with varying complexities. In an Extremum Graph, we directly classify each saddle as either connecting neighbouring maxima (creating a ridge) or neighbouring minima (creating a valley) via cancellation. Extremum graphs form a natural multiresolution structure that allows the user to

suppress noise and enhance topological features via the specification of a persistence range. This approach preserves the local geometric structure of the scalar field, including structural cycles that are useful for exposing symmetries in the data. In this study an attempt has been taken to create extremum graphs (from a given set of edge lists) at each time step of a varying scalar field defined by spatiotemporally varying Gaussian functions. The Poly-data graph has been created, using vtk library functions(vtkPoints, vtkCell Array, vtlLines) in python and uploaded the vtp files and gaussian raw data in Paraview to do visualisation. The Extremum Graph supported visualization will be extended to other datasets such as Viscous finger to visualize the temporal interactions between critical points and detect topological variations.

Keywords or phrases: Topological spines, scalar field, extremum graph, Morse-Smale complex, viscous finger