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Titel der Dissertation: Flow Visualization and Analysis Based on Integral Line Predicates

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Zusammenfassung:
Predicates are functions that return Boolean values. They are an essential tool in computer science. A close look at flow feature definitions reveals that they can be seen as point predicates that tell if a specic feature exists at a certain point. Besides the information about features, scientists and engineers like to know the overall behavior of all particles in the flow, typically in connection with the important features in their application domain. We call this a structure definition for the flow. Since particle traces can be described as integral lines, this thesis introduces integral line predicates as functions that tell the user about the connection between integral lines and features selected by the user.

For steady vector fields, the idea of integral line predicates leads to streamline predicates, that examine, whether a streamline has a given property. Evaluating all streamlines results in characteristic sets, pooling all streamlines with similar behavior with respect to a given predicate. Based on these sets a flow structure can be defined, showing the part of the flow with exactly the behavior defined by the streamline predicates. This allows flow structure definitions flexibly adapted to typical analysis tasks arising in flow studies and taylored to the users' needs. It can be shown that a successful example for such a structure definition is the already known flow topology.

Besides the known trade-off between suficient coverage in the field and cluttering of streamlines, the typical user question is: Where should I start my streamlines to see all important behavior? Based on the skeletal representation of the topology of flow structures, a 3D streamline placement is proposed, that on the one hand exactly illustrates the desired property of the flow and on the other hand takes the topology of the specic flow structure into account. A heuristic and a deterministic approach is presented and their advantages and disadvantages are discussed.

For unsteady vector fields the concept of integral line predicates leads to pathline predicates. The visualization of the resulting unsteady flow structure provides a visual description of overall flow behavior with respect to the user's interests. Furthermore, this flow structure serves as a basis for pathline placement tailored to the requirements of the application.