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STRING 3: An Advanced Groundwater Flow Visualization Tool

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The visualization of 3D groundwater flow is a challenging task. Previous versions of our software STRING [1] solely focused on intuitive visualization of complex flow scenarios for non-professional audiences. STRING, developed by Fraunhofer ITWM (Kaiserslautern, Germany) and delta h Ingenieurgesellschaft mbH (Witten, Germany), provides the necessary means for visualization of both 2D and 3D data on planar and curved surfaces. In this contribution we discuss how to extend this approach to a full 3D tool and its challenges in continuation of Michel et al. [2]. This elevates STRING from a post-production to an exploration tool for experts.

In STRING moving pathlets provide an intuition of velocity and direction of both steady-state and transient flows. The visualization concept is based on the Lagrangian view of the flow. To capture every detail of the flow an advanced method for intelligent, time-dependent seeding is used building on the Finite Pointset Method (FPM) developed by Fraunhofer ITWM.

Lifting our visualization approach from 2D into 3D provides many new challenges. With the implementation of a seeding strategy for 3D one of the major problems has already been solved (see Schröder et al. [3]). As pathlets only provide an overview of the velocity field other means are required for the visualization of additional flow properties. We suggest the use of Direct Volume Rendering and isosurfaces for scalar features. In this regard we were able to develop an efficient approach for combining the rendering through raytracing of the volume and regular OpenGL geometries. This is achieved through the use of Depth Peeling or A-Buffers for the rendering of transparent geometries.

Animation of pathlets requires a strict boundary of the simulation domain. Hence, STRING needs to extract the boundary, even from unstructured data, if it is not provided. In 3D we additionally need a good visualization of the boundary itself. For this the silhouette based on the angle of neighboring faces is extracted. Similar algorithms help to find the 2D boundary of cuts through the 3D model.

As interactivity plays a big role for an exploration tool the speed of the drawing routines is also important. To achieve this, different pathlet rendering solutions have been developed and benchmarked. These provide a trade-off between the usage of geometry and fragment shaders. We show that point sprite shaders have superior performance and visual quality over geometry-based approaches. Admittedly, the point sprite-based approach has many non-trivial problems of joining the different parts of the pathlet geometry.

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