Reduced Representations for In-Situ Visualization

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Storage and network bandwidth constraints increasingly become the limiting factor for overall compute performance. In-situ visualization aims to alleviate this bottleneck by transforming the data locally on the respective simulation node into an intermediate visualization representation of reduced size. This allows to generate and store visualizations at a much higher resolution, both with respect to space and time, than what the simulation node would otherwise be able to store permanently in terms of full raw data. We discuss the concept and implementation of in-situ visualization approaches, and outline how they can be embedded in the context of large-scale simulations, with a particular focus on the efficient visualization of volume data. An integral part of this process are the intermediate visualization representations, which usually not only allow for reduced cost for storage and transfer but also for image synthesis in comparison to what is induced with the original data stemming directly from the simulation. In-situ visualization representations typically achieve this by restricting the degrees of freedom that can be adjusted interactively during the final display stages, i.e., some may be removed completely, while others might be subject to certain limitations or drawbacks. In general, the more the exploration possibilities are restricted, the higher is the potential for data size reduction.

We give a brief overview on commonly employed approaches, and then discuss the basic ideas and characteristics of representations that we have developed in recent years in more detail. Our volumetric depth images (VDIs) follow a view-dependent approach, i.e., they are optimized with respect to a certain camera position, with the goal to combine the high quality of images and the explorability of interactive techniques. VDIs represent an intermediate abstraction of color-mapped volume samples, clustered along viewing rays originating from the respective camera position. We further outline the extension of VDIs to a space-time representation: further clustering the the data both across viewing rays in space as well as in time allows for efficient compression with standard entropy encoding schemes. We also discuss a view-independent representation that only incorporates time steps that were explicitly selected based on their relative importance with respect to previous time steps. Similar to VDIs, the generation of this representation is based on user-defined transfer function settings, yet it still preserves some flexibility to adapt the color mapping. We finally conclude with a discussion of the requirements, advantages, and shortcomings of in-situ visualization in general and different representations in particular.

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