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Research domain(s), discipline(s)/sub-discipline(s)

Open, interoperability standards for 3D graphics and data visualization

Title of Response

Open Analytic Rendering Interoperability Standard for Scientific Visualization

Abstract

Recent advances in rendering technology such as real-time ray tracing, have great promise to significantly impact data visualization, however, using these graphical techniques can come at the cost

of increased application development cost and complexity. Traditional low-level graphics APIs provide powerful rendering hardware abstractions but may be too low-level and development-heavy for many visualization applications to utilize effectively and the proliferation of higher-level API solutions leads to ecosystem fragmentation as visualization applications need to be ported to multiple, incompatible platforms Consequently, the Khronos Group, an open standards consortium, initiatied work on a higher-level analytic rendering API standard that could significantly reduce software development costs and make advanced rendering techniques more accessible and widely used by visualization applications for which rendering is necessary. The Analytic Rendering Exploratory Group at Khronos consists of independent visualization software vendors, visualization experts and hardware vendors including Oak Ridge National Laboratory, Texas Advanced Computing Center, Kitware, SURVICE Engineering and Delta-H Engineering, Intel and NVIDIA among others. Additional funding for this initiative would amplify existing efforts, enabling the build out of a robust ecosystem of tools, conformance tests and educational and outreach materials making advanced rendering capabilities far more accessible to the scientific visualization community.

Question 1 (maximum 400 words) – Data-Intensive Research Question(s) and Challenge(s). Describe current or emerging data-intensive/data-driven S&E research challenge(s), providing context in terms of recent research activities and standing questions in the field. NSF is particularly interested in cross-disciplinary challenges that will drive requirements for cross-disciplinary and disciplinary-agnostic data-related CI.

Recent advances in rendering technology, especially the introduction of real-time ray tracing, has great promise to significantly impact data visualization by providing physically accurate imagery and visual cues for an intuitive understanding of complex data. However, using these graphical techniques can come at the cost of increased application development cost and complexity. Graphics APIs such as Vulkan, and its upcoming ray tracing extension, provide powerful rendering hardware abstractions, but may be too low-level and development-heavy for many visualization applications to utilize effectively. Consequently, several hardware vendors have developed higher-level rendering APIs, such as Intel's OSPRay and NVIDIA's VisRTX, but this leads to ecosystem fragmentation as visualization applications need to be ported to multiple, incompatible platforms.

Question 2 (maximum 600 words) – Data-Oriented CI Needed to Address the Research Question(s) and Challenge(s). Considering the end-to-end scientific data-to-discovery (workflow) challenges, describe any limitations or absence of existing data-related CI capabilities and services, and/or specific technical and capacity advancements needed in data-related and other CI (e.g., advanced computing, data services, software infrastructure, applications, networking, cybersecurity) that must be addressed to accomplish the research question(s) and challenge(s) identified in Question 1. If possible, please also consider the required end-to-end structural, functional and performance characteristics for such CI services and capabilities. For instance, how can they respond to high levels of data heterogeneity, data

integration and interoperability? To what degree can/should they be cross-disciplinary and domain-agnostic? What is required to promote ease of data discovery, publishing and access and delivery?

Visualization applications must be ported to multiple rendering APIs, and as this number of APIs increases, so, too, does the work for developers who must port their applications to each different rendering API. An open, higher-level Analytic Rendering API standard could significantly reduce software development costs while making advanced rendering techniques more accessible and widely used by visualization applications for which rendering is just a necessary technique to be utilized, while providing portability to multiple platforms that support the common API. The goal of the initiative at Khronos is to define a high-level API to simplify the development of visualization applications while leveraging the full potential of modern rendering capabilities. The Analytic Rendering Exploratory Group is proposing to define a concise, high-level API as a contract between visualization domain experts and rendering technologists, enabling a "win-win" by simplifying implementation and deployment for both groups. Some key goals include: - Create an open, royalty-free API that is platform independent – enabling visualization applications to portably access diverse rendering backends - Provide visualization applications access to the full range of modern rendering capabilities and engines, including – but not restricted to – the latest ray tracing techniques - Free visualization domain experts from the necessity of dealing with non-trivial rendering details and multiple incompatible backend rendering APIs - Enable graphics experts developing rendering backends to avoid the need to implement domain-specific functionality and optimizations through supporting a well-designed, cross-platform API standard – and hence making their backend renderers accessible to a wider diversity of disciplines and audiences. Rather than specifying the details of the rendering process, the Analytic Rendering API would enable a visualization application to simply describe the relationship between objects in a scene to be rendered and leave the details of the rendering process to a backend renderer. Unlike more general scene graph APIs, the proposed initiative would focus specifically on the needs of the visualization domain - and as with any successful interoperability standard, the proposal would enable and encourage a diverse range of competitive API implementations.

Question 3 (maximum 300 words) – Other considerations. Please discuss any other relevant aspects, such as organization, processes, learning and workforce development, access and sustainability, that need to be addressed; or any other issues more generally that NSF should consider.

The creation of this Analytic Rendering API is currently being undertaken at the Khronos Group. The Khronos Group is an open industry consortium of over 150 leading hardware and software companies creating advanced, royalty-free, acceleration standards for 3D graphics, Augmented and Virtual Reality, vision and machine learning. Khronos standards include Vulkan®, OpenGL®, WebGL™, OpenCL™, SYCL™ and glTF™. Khronos members are enabled to contribute to the development of Khronos specifications, are empowered to vote at various stages before public deployment and are able to accelerate the delivery of their cutting-edge accelerated platforms and applications through early access to specification drafts and conformance tests. The Analytic Rendering Exploratory Group at Khronos consists of independent visualization software vendors, visualization experts and hardware vendors with

the common goal to define an API to simplify the development of visualization applications in a platform independent way. Current participating organizations include Oak Ridge National Laboratory, Texas Advanced Computing Center, Kitware, SURVICE Engineering and Delta-H Engineering, Intel and NVIDIA among others. https://www.khronos.org/exploratory/analytic-rendering/ Additional funding for this initiative would amplify existing efforts, enabling the build out of a robust ecosystem of tools, conformance tests and educational and outreach materials, making advanced rendering capabilities far more accessible to the scientific visualization community.

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