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STAR-CCM+ v9.02 Preview: Volume Rendering

Matthew Godo
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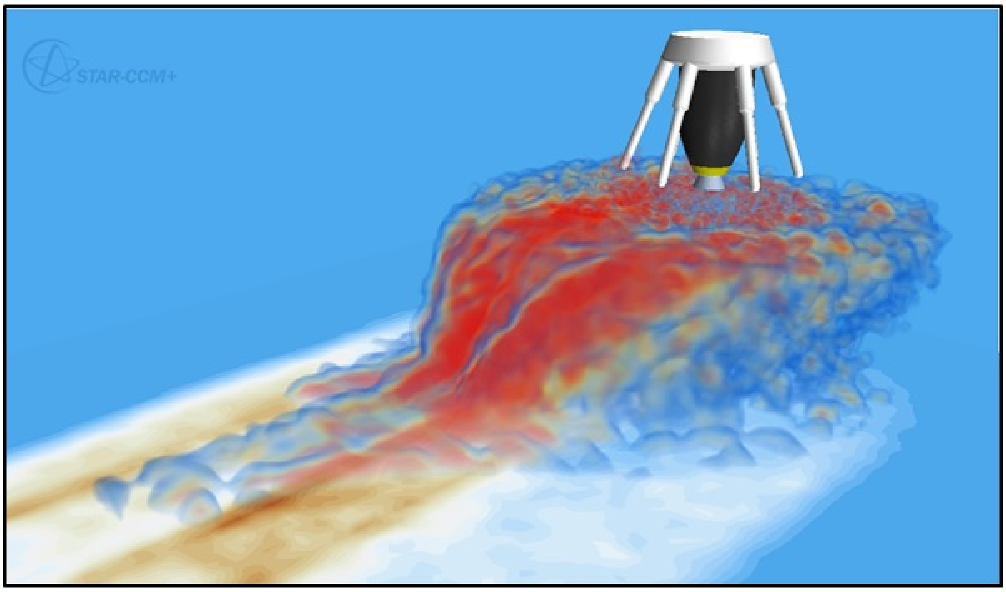
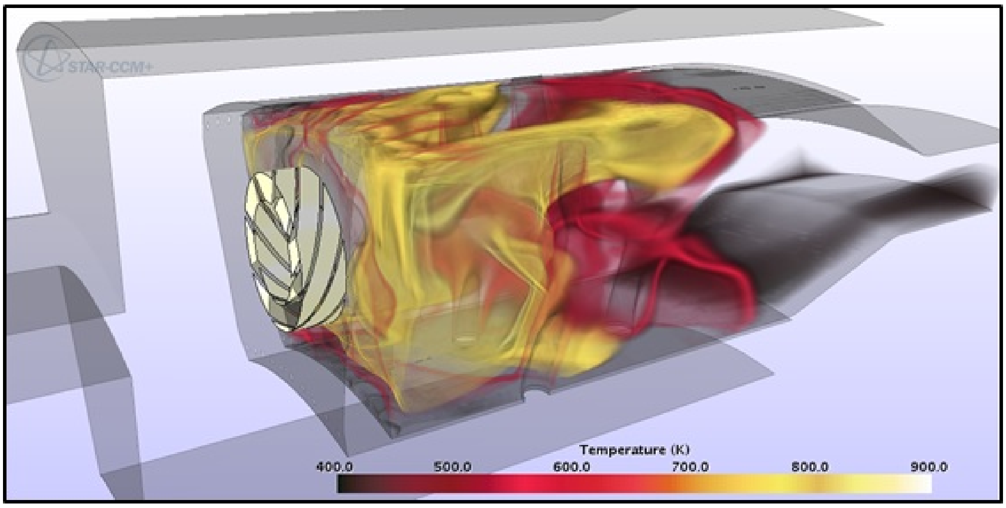
Volume rendering, a well-known scientific visualization method, is being introduced with our latest version of STAR-CCM+! (v9.02)



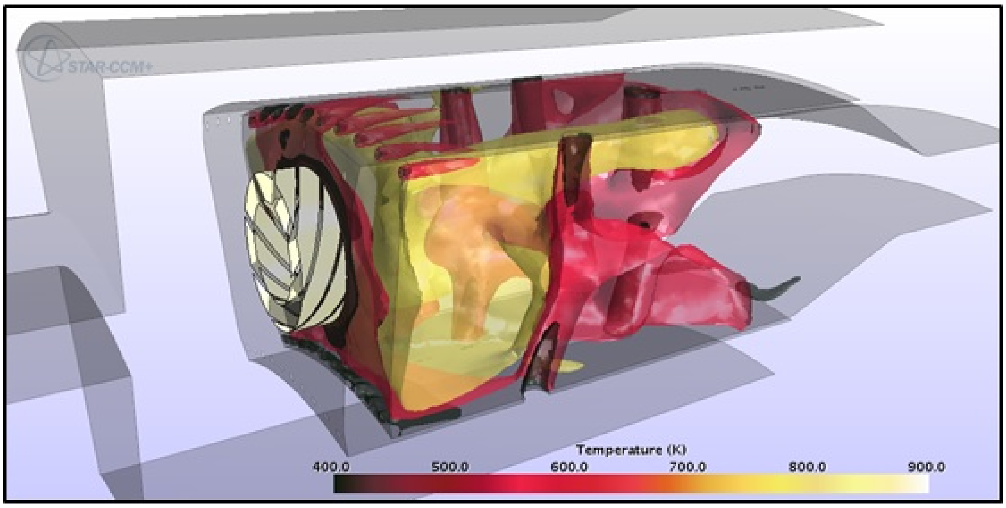
A Spray Nozzle showing a Volume Render of the Droplet Volume Fraction

When you hear the phrase ?Volume Rendering?, the first thing that may come to mind is a collection of highly compelling medical images depicting our internal organic structures. You might also recall movie blockbuster special effects showing things like clouds, smoke, storms and explosions. And you might be thinking that these high-end visualizations are the exclusive domain of dedicated medical imaging facilities and animation powerhouses like Dreamworks and Pixar. What would you think about being able to create a ?Volume Rendered? depiction of your CFD results on your laptop? And why would you want to in the first place?

When we examine our CFD results, we traditionally use ?surfaces? to understand and communicate our findings. We look at boundaries within our regions to see what is happening at inlets, outlets and walls with various boundary conditions imposed. Spanning the volume of our regions, we create derived planes to understand spatial variations in scalar functions. Iso-surfaces give us a way to look more closely inside the region volume but even these visualization tools are still fundamentally ?surfaces?. In specifying the location of a derived plane or value of an iso-function, we are making an assumption that we know where to look for problems. For complex models, even with experience, it becomes increasingly possible during postprocessing efforts to miss critical areas where device performance may be adversely affected.



Volume Rendering of Temperature within a Combustion Chamber



Iso-surfaces of Temperature in a Combustion Chamber

Volume rendering on the other hand is a ?volume-based? visualization method. In the volume render illustration of the Combustion Chamber (above), we can not only see the fine structures associated with temperature variations, but we also have an idea of where temperature gradients are high or low. Higher scalar gradients are more opaque whereas lower ones are more transparent. If we compare the volume rendered illustration to a series of iso-surfaces, the utility of this new visualization method immediately becomes clear. Which scientific visualization of this combustion chamber would you show to your manager?

While volume rendering technology isn?t new, accessibility to it is. Anyone familiar with video games can appreciate how graphics cards continue to aggressively push the boundaries of capability and performance and volume rendering is perfectly suited to take advantage of these steady hardware improvements. But even the best graphics card is going to struggle if data management is not well considered.

Why is Data Management Relevant to this Discussion?
Let?s step back for a moment... Volume rendering generates a picture from a set of voxels. Voxels are box-shaped volume elements, arranged on a regular grid, to which the attributes of opacity, color and lighting can be applied. For volume rendering to work, we need to divide and conquer our model domain once more, this time breaking it down into a resampled volume instead of a mesh.

Resampled volume can get expensive so a trade-off has to be made between the time and resources needed for resampling versus the desired end quality. To this end, we?ve included controls that easily manage the cost of volume rendering by changing the cell size to voxel ratio as illustrated below. One of our unique features is that our resampling method is adaptive. As you can see, the areas closer to the blade surfaces have a noticeably higher voxel refinement. Resampling methods that use a constant voxel size will not only require more resources (since they will be more dense than they need to be in the far field regions), but will be susceptible to loss of detail (because they will be too coarse) particularly near surfaces where vortex shedding is initiated. Resampling is also a fully parallelized operation on our servers. Even with large models, the time needed to change from say, vorticity magnitude to a mass fraction scalar, will be comparatively small.

Fora quick start, you can snap your resampling target volume directly to a part. For some applications, such as trying to capture the downstream wake for a moving object, you can modify your target volume interactively, resampling only the partial volume of interest. This approach lets you reduce your volume rendering costs while increasing your throughput.

Fine-tune controls balance resampled volume size against render quality

Our research and development of this scientific visualization method combines many ?state-of-the-art? techniques to deliver a high performance and cost-effective implementation. Volume rendering, along with resampling as a new derived part, will be in your hands with the STAR-CCM+ 9.02 release. Special colormaps, targeted for use with volume rendering will be included and more will become available as this new capability matures. Looking slightly ahead past the 9.02 release, we will deliver a fully interactive colormap editor to let you fully personalize your own colormaps. Additional lighting methods will also be added for further control, making your volume rendered visualizations even more realistic.

Look for STAR-CCM+ 9.02 to be released at the end of February and stay tuned to our CD-adapco Blog for all the latest information!