New method efficiently renders granular materials at multiple scales

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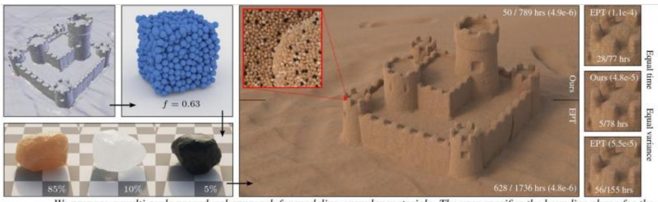

We propose a multi-scale procedural approach for modeling granular materials. The user specifies the bounding shape for the aggregate material (top left), selects a pre-packed tile of grain bounding spheres (top middle), within which we instantiate randomly rotated copies of the selected exemplar grains (bottom left) according to the specified mixing ratios. The SANDCASTLE *contains about 2 billion grains, each composed of approximately 200 k triangles. We report the high-order / total render times in hours and the variance in parentheses. Our approach (top half) renders the high-order scattering over 12× (50 vs. 628 hrs) faster than explicitly path tracing (EPT) the individual grains (bottom half) while providing visually indistinguishable results. The insets on the right provide equal time and equal variance comparisons.*

Computer graphics researchers have developed a way to efficiently render images of sand castles, gravel roads, snowmen, salt in a shaker or even ocean spray - any object consisting of randomly oriented, but discernible grains - that look realistic whether viewed from afar or up close.

The new method, developed by Disney Research in collaboration with researchers from Karlsruhe Institute of Technology, ETH Zurich, Cornell University and Dartmouth College, employs three different types of rendering techniques depending on the scale at which the object is viewed.

A sand castle scene created by the researchers, which contains about two billion grains, appears uniformly light brown and continuous when seen from a distance. But when the view zooms in, individual grains of three different colors are apparent.

Details of the method will be presented at ACM SIGGRAPH 2015, the International Conference on Computer Graphics and Interactive Techniques, in Los Angeles Aug. 9-13.

"Granular materials are common in our everyday environment, but rendering these materials accurately and efficiently at arbitrary scales remains an open problem in computer graphics," said Marios Papas, a Ph.D. student in computer graphics at Disney Research and ETH Zurich. The rendering framework he and his colleagues used to tackle this problem adapts to the structure of scattered light at different scales.

At the smallest scale, they consider the geometry, size and material properties of the individual grains and the density at which they are packed together. They capture the appearance of these individual grains with a rendering technique called path tracing. This traces many light paths from each pixel back to their sources, building a highly detailed and realistic model of the aggregate material. Using just a few paths per pixel typically results in very noisy images that are quick to compute, but high-quality images require simulating thousands of such light paths per pixel.

The intense computation required for this technique isn't feasible for the entire object, which might contain millions or billions of grains. So, as the scale increases and as it becomes harder to track which rays bounced off which grains, they use a different rendering technique, volumetric path tracing, which approximates the material as a continuous medium and requires less computation. While typically used to render more tenuous atmospheric effects like clouds or smoke, the researchers showed how this technique can also be used to accurately simulate the way light scatters within such granular materials at larger scales.

At even greater scales, particularly for materials that are highly reflective such as snow or spray, they use a third technique leveraging the diffusion approximation.

"It would be possible to use any one of these techniques to render the image, but path tracing the individual grains would require prohibitive amounts of computation time and the other techniques would fail to capture the appearance of individual grains at small scales," said the project lead Wojciech Jarosz, formerly a senior research scientist at Disney Research and now an assistant professor of computer science at Dartmouth College.

"One of our core contributions is showing how to systematically combine these disparate methods and representations to ensure visual consistency between grains visible at vastly different scales, both across the image or across time in an animation," Jarosz said.

Depending on the type of material, the hybrid approach can speed up computation by tens or hundreds of times in comparison to renderings done entirely with path tracing, according to the researchers' calculations.

More information:
www.disneyresearch.com/publica … -granular-materials/

Provided by Disney Research