How flattening our dimension can bring better graphics into the fold

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In order to create 3-D models in the field of computer graphics, thin sheets of material are layered together to create a single object. Dr. Scott Schaefer, professor in the Department of Computer Science and Engineering at Texas A&M University, is focused on peeling back those layers in order to create more realistic graphics than ever before.

These types of graphics are composed of numerous triangular surfaces; however, geometry is only one aspect of how we perceive an object. Generally we interpret surfaces by their color or how light interacts with the surface, all of which make the surface appear more realistic.

These colors are usually applied to the surface via texture mapping, which is a process that relies on the parameterization of a surface to map a two-dimensional image onto a three-dimensional surface. Parameterization is the flattening of a piece of a surface to the two-dimensional domain, which is Schaefer's current focus.

"We take a surface, cut it along a seam and then flatten it onto the floor," Schaefer said. "This flattening of a shape creates a map between the 2-D image and the 3-D shape. Colors on the image appear on the corresponding part of the 3-D surface, which is how nearly every 3-D model is colored today."

This flattening can introduce some distortion into the shape and most current parameterization methods are focused on reducing this distortion.

However, Schaefer's research centers on how the distortion that occurs is measured and optimized, as well as enforcing a mathematical property called a bijection. A bijection means that triangles do not fold over or overlap in any way during the flattening process.

"Imagine you had a piece of cloth that was cut out," Schaefer said. "You could lay it on the floor in many ways. A bijection would say that there are no folds in the cloth and that pieces of the cloth did not lie on top of each other on the floor."

While the property sounds easy, it has been nearly impossible to obtain while simultaneously minimizing distortion. Schaefer and his research team have successfully developed a method for efficiently optimizing parameterizations that produce a bijection.

His more recent work attempts to speed up this optimization by understanding the shape of the distortion function in a higher dimensional space. By moving along low distortion, curved paths instead of straight lines, it is possible to speed up the optimization to be hundreds or even thousands of times faster. Such an advancement would make creating realistic deformations, which currently rely on expensive non-linear optimization, fast and interactive.

Schaefer began studying parameterization while teaching a game development course at Texas A&M. In the class, students were asked to build 3-D models, but ran into difficulty while attempting to paint the surfaces of the models because the methods in commercial tools did not enforce bijective maps between the 2-D and 3-D shapes.

"This became the motivation for my search for a better way of solving this problem," Schaefer said.

Parameterization is a fundamental tool in the field of computer graphics, so it is possible that the next movie you watch or video game you play will benefit from the results of Schaefer's research.

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