Professor Etienne Vouga

Madhav Narayan

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Nearly all animated films today feature physically realistic visuals, from the rich underwater expanse of *Finding Nemo* to the subtle human-like expressions of the toys in *Toy Story.* However, having computers model physical objects and real-world phenomena isn't exactly straightforward: Rapunzel's hair in *Tangled*, for instance, took *six years* of programming to get right. Many seemingly simple physical phenomena like flowing water, colliding bodies, and "moving" cloth (say, a flag in a windy environment) are in fact defined by complex mathematical models that can be hard for computers to simulate realistically. The applications of realistic simulations, however, are many — animation, engineering, medicine, architecture — and it is thus worthwhile to develop computational techniques to achieve such high-quality models.

That's where scientists like Dr. Etienne Vouga come in.

Dr. Etienne Vouga is an Assistant Professor of Computer Science at the University of Texas at Austin. His research interests are in computer graphics, a vibrant field of study at the intersection of computer science, physics, and mathematics. His work focuses on leveraging the theoretical (mathematical) properties of physical objects to create accurate computer simulations. In particular, he works on *physical simulation* — modeling real-world physical phenomena — and *geometry processing* — employing a geometric understanding of objects to develop efficient modeling techniques.

Part of Professor Vouga's research explores how physical phenomena can be *approximated* well by computers. A key constraint faced by many computational tasks is that they can be too "expensive" to compute. This means that a task might require so much processing or storage that it becomes impractical to actually perform in practice. For a computer's simulation of, say, flowing water to look realistic, it must work with *smooth* physical models (equations) that encapsulate the behavior of flowing water. Alas, taking full advantage of the detail and precision these models offer would require us to process way more data than we can afford to! To work around this, we can instead approximate these models using a limited amount of data. These approximations do give up *some* realism, but they are much more feasible to compute, and are designed to minimize the loss in quality. In his research, Professor Vouga designs approximations for everyday objects like cloth, paper, leaves, and hair; in particular, physical objects that are elastic and malleable. In fact, his research contributed to the animation of the hair in *Tangled*! His work on the behavior of many bodies colliding simultaneously intuitively modeled and enabled better simulations of thousands of individual strands of hair interacting with each other.

In studying the geometric properties of the objects we consider useful to model, Professor Vouga seeks to cultivate a deeper, more holistic understanding of their structural properties. In a recent talk on breakthroughs and challenges in graphics research, he highlighted that such an understanding was key to crafting better solutions for many problems, as well as designing approaches to previously unsolved problems. One path he is interested in exploring is formalizing the characteristics that define a particular family of objects. Each unique object in the family, then, could itself be described using only a small (computationally feasible) amount of information. For example, if we could describe the (structural) properties common to all leaves, then we could construct individual models for, say, a four-leaf clover and a maple leaf by simply building on our “base” leaf model. Similarly, we could also describe how an object changes state over time, enabling us to realistically simulate processes like the growth of a tissue or the construction of a building.

The ability to glean useful structural information about real-world objects would also be a significant breakthrough in related areas like 3D printing. Most 3D printers today do well at recreating the shape (outline) of an object, but are unable to reproduce the object’s physical characteristics. This greatly limits the utility of 3D printing. However, if we could understand some of these physical characteristics better — an object’s internal structure, composition, texture, sound, or malleability — then we would be able to 3D print much more realistic objects. The improved realism in this case would go beyond aesthetics, enabling us to effectively manufacture actual, functioning tools and objects.

In addition to its use in *Tangled*, Professor Vouga’s research has contributed to special effects in *The Hobbit* as well as to Artec’s *Shapify* tool, which allows one to convert a 3D portrait of themselves into a statue. Like most areas of study that draw upon many other fields, computer graphics itself stands to have a big impact on many other disciplines, from arts and aerospace, to mathematics and medicine. In giving computers vision of the world, Professor Vouga and his colleagues add more meaning to ours.