Taking the Pain out of Painting

In a digital world, BU computer scientists are working to remove hurdles to creativity

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- **Emily Whiting's team is removing hurdles to creativity by simplifying software**
- **She wants computers to automatically solve technical challenges in the design process**
- **As an exercise, her group created software that can make a watercolor from a digital image**

Watercolor paintings have long been prized for their individuality and expressiveness, and for good reason—reproductions can never quite match the subtle ways that colors appear on paper, or the delicate gradients that water creates as it soaks into the paper's fibers, dragging pigment along with it. Learning to control these effects can take years of practice, even for skilled artists.

Emily Whiting, a Boston University assistant professor of computer science, is developing new ways to make watercolor technique more accessible to lay artists, as part of a larger goal to make complex design software more accessible to nonscientists. The project is a collaboration between Whiting, visiting scholar Athina Panotopoulou (a PhD student at Dartmouth College), and Sylvain Paris, a researcher at Adobe Systems, the company that makes software like Photoshop. Together, the group has designed a way to create watercolor paintings

The program they've created, which Panotopoulou presented at the Eurographics 2018 conference in April, lets even neophyte users start with a basic digital image that they use to create a sort of "model watercolor" onscreen. With a few clicks, they can control pigments, shading, blend rate, and other attributes. Once they're finished, the software automatically creates a separate digital layer for each color, much like existing photo-editing software.

To turn the digital image into a physical watercolor, Whiting's team sends the patterns on each layer into a laser cutter, which cuts and etches the patterns' intricate details into plywood. The team then applies a different shade of watercolor paint to each of the wood blocks, and presses each layer in sequence onto paper, re-creating the image. The system even includes templates for adding liquid latex fluid, which can mask areas where no paint should touch, and templates for (of course) applying water, which creates those beautiful washes of color that make the paintings so unique.

Whiting's team uses dozens of laser-etched wood panels like this to "print" detailed watercolors on paper. Photo by Cydney Scott

"We were avoiding a system where the artwork is printed with a standard color laser printer. We wanted to create an actual watercolor painting with real pigments," says Whiting. "When you think of computer-generated art, that usually means every copy will be identical. Our method lets you create something that has a physical aspect to it, so you wind up with slight variations in every copy, so each piece is unique."

While the process may sound a bit convoluted, it actually represents an exercise in simplicity. By using advanced software and computerized manufacturing tools like laser cutters, it could let a relative novice create works that look like they were made by a professional. In one of Whiting's test pieces, a tiny bird looks quizzically at the viewer, its plumage expertly blended in a wash of browns and grays. In another, the colors of a single flower blend intermediary—a sort of digital "hand" that executes what would otherwise be complex painting techniques automatically, so users can go from concept to final product without worrying about how to get there. To that end, Whiting says, her lab's watercolor system represents a way to remove technical hurdles for users so they can focus on creativity.

Human-centered computing

Whiting's team specializes in simplifying complex tasks. Her group, called the BU Shape Lab, works with powerful 3D design software and advanced fabrication devices like 3D printers, laser cutters, and computer-controlled routers, yet seeks to humanize the experience of using them. Whiting calls her work "human-centered computing"—in other words, making powerful computerized tools easier for non–computer scientists to use.

Existing computer design software, she notes, tends to come in extremes: it's either so basic that it's only good for early sketches, or so utterly feature-rich that only professionals can really master it.

"There are so many complexities involved in design that it can be overwhelming or impossible to navigate all the possibilities," she says. "Computers should aid exploration and creation, not hinder it. What you really need is a process where a human can easily explore different options and try out ideas, while staying within the bounds of important design constraints."

To that end, she adds, the Shape Lab seeks to create tools that are both powerful and approachable—and that let designers meet aesthetic goals without worrying about the myriad challenges that come with making something for fabrication.

the 3D printed part should prioritize strength over details, or how its shell needs to be to maintain its form, to name a few. All these factors create obstacles in the creative process, Whiting says—so instead, she wants to make them disappear into the background.

The group's watercolor project is a perfect example of this ideal. It's essentially a tool that uses technology as a middle man, taking much of the complexity out of computer-based design. Behind the scenes, it performs complex calculations that crunch numbers, analyze images, and ultimately generate the designs users want, while keeping the software simple to use.

Starting with a digital image (top left), Whiting's software separates color and shading into individual layers that are laser-etched onto plywood (top right). By applying pigment and water to each layer and pressing it onto paper, her team re-creates a watercolor version of the original (bottom). Marilyn Monroe photograph by Milton H. Greene © 2018 Joshua Greene • archiveimages.com. Photos of woodblocks and watercolor courtesy of Emily Whiting

Cooler casts, stable spinners

to make 3D design and fabrication user-friendly—most recently, by creating a tool to generate custom 3D-printed casts for patients with broken bones.

Traditional casts, which are made of fiberglass or plaster, are not breathable, and can create uncomfortably warm temperatures on patients' skin. Starting with thermal scans of a patient's forearm, Shape Lab researchers have created software that generates a plastic mesh cast instead—a sort of high-tech web of geometrical shapes. In areas where the patient runs hottest, those shapes are bigger, opening up larger holes in the cast to let heat escape. At areas of the scan that come up cooler, the shapes are more tightly packed together. The final product maximizes comfort while still maintaining a stiff structure to protect damaged limbs—yet all users have to do is take an infrared scan of a patient's arm, and the software creates a model that can be immediately 3D printed.

Whiting's team has also used this computer-aided design process to create spinning tops with odd shapes, like a dancing elephant. While a talented sculptor could certainly create those forms, making them spin in a stable way is far more challenging—it involves finding the centers of mass and inertia for the object, and placing the pivot point there. For humans, that's a serious challenge. But for a computer, it's trivial, Whiting notes. Using the digital 3D design of the elephant, the Shape Lab's software analyzes its overall form, and can automatically add or remove materials inside the 3D model, putting the toys back into balance. Even though they look ungainly, they still spin smoothly and effortlessly.

"Being able to control designs without the need for an engineering degree—and still have your ideas turn out functional and fabrication-ready in the end—that's really what we're after," Whiting says. "We want computers to support the process of creative exploration."