Researchers show soft sides with layered fabric 3-D printer

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A team from Disney Research and Carnegie Mellon University have devised a 3-D printer that layers together laser-cut sheets of fabric to form soft, squeezable objects such as bunnies, doll clothing and phone cases. These objects can have complex geometries and incorporate circuitry that makes them interactive.

"Today's 3-D printers can easily create custom metal, plastic, and rubber objects," said Jim McCann, associate research scientist at Disney Research Pittsburgh. "But soft fabric objects, like plush toys, are still fabricated by hand. Layered fabric printing is one possible method to automate the production of this class of objects."

The fabric printer is similar in principle to laminated object manufacturing, which takes sheets of paper or metal that have each been cut into a 2-D shape and then bonds them together to form a 3-D object. Fabric presents particular cutting and handling challenges, however, which the Disney team has addressed in the design of its printer.

The layered-fabric printer will be described at the Association for Computing Machinery's annual Conference on Human Factors in Computing Systems, CHI 2015, April 18-23 in Seoul, South Korea, where the report has received an honorable mention for a Best Paper award. In addition to McCann, the team included Huaishu Peng, a Ph.D. student in information science at Cornell University, and Scott Hudson and Jen Mankoff, both faculty members in Carnegie Mellon's Human-Computer Interaction Institute.

Last year at CHI, Hudson presented a soft 3-D object printer he developed at Disney Research that deposits layers of needle-felted yarn. The layered-fabric printing method, by contrast, can produce thicker, more squeezable objects.

The latest soft printing apparatus includes two fabrication surfaces - an upper cutting platform and a lower bonding platform. Fabric is fed from a roll into the device, where a vacuum holds the fabric up against the upper cutting platform while a laser cutting head moves below. The laser cuts a rectangular piece out of the fabric roll, then cuts the layer's desired 2-D shape or shapes within that rectangle. This second set of cuts is left purposefully incomplete so that the shapes receive support from the surrounding fabric during the fabrication process.

Once the cutting is complete, the bonding platform is raised up to the fabric and the vacuum is shut off to release the fabric. The platform is lowered and a heated bonding head is deployed, heating and pressing the fabric against previous layers. The fabric is coated with a heat-sensitive adhesive, so the bonding process is similar to a person using a hand iron to apply non-stitched fabric ornamentation onto a costume or banner.

Once the process is complete, the surrounding support fabric is torn away by hand to reveal the 3-D object.

The researchers demonstrated this technique by using 32 layers of 2-millimeter-thick felt to create a 2 ½-inch bunny. The process took about 2 ½ hours.

"The layers in the bunny print are evident because the bunny is relatively small compared to the felt we used to print it," McCann said. "It's a trade-off—with thinner fabric, or a larger bunny, the layers would be less noticeable, but the printing time would increase."

Two types of material can be used to create objects by feeding one roll of fabric into the machine from left to right, while a second roll of a different material is fed front to back. If one of the materials is conductive, the equivalent of wiring can be incorporated into the device. The researchers demonstrated the possibilities by building a fabric starfish that serves as a touch sensor, as well as a fabric smartphone case with an antenna that can harvest enough energy from the phone to light an LED.

The feel of a fabricated object can be manipulated in the fabrication process by adding small interior cuts that make it easy to bend the object in one direction, while maintaining stiffness in the perpendicular direction.

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