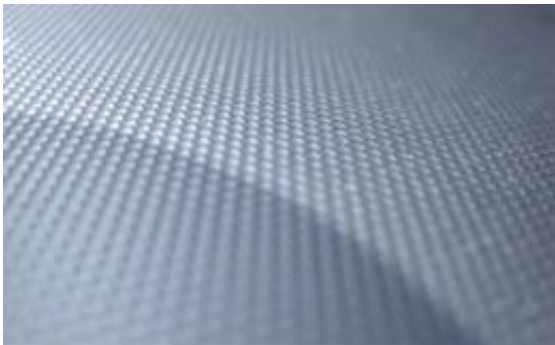


# Photos reflect light like 3D objects with novel printing technology

August 14 2012, By Tim Stephens

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An image printed on reflectance paper responds to the direction from which it is illuminated. The reflectance paper is covered with dimples that reflect light from different directions. See video below for more details.

A novel printing method yields photos that respond to different angles of light the same way a three-dimensional object does. The technique, which uses specially designed "reflectance paper" covered with thousands of tiny dimples, was developed by a team of researchers at the University of California, Santa Cruz, Hewlett-Packard Laboratories, and 3M.

James Davis, an associate professor of computer science in the Baskin School of Engineering at UC Santa Cruz, explained that ordinary printed photos look the same regardless of the angle of the light because flat paper can't reflect light the way three-dimensional objects do.

"If the paper is flat, it will always look flat no matter what you print on it. So the question became how to get the surface of the paper to have geometry to it," Davis said. "With the reflectance paper, for each pixel we have a little dimple that has all angular directions on its surface. Now we can print ink over it in a way that controls the angles of light that will be reflected from each pixel."

The mathematical "reflectance function" describes how light is reflected from each point on an object. Measuring the reflectance functions for an object or scene can be done by taking photographs lit from many different lighting directions. Art historians and restorers use these techniques for documenting important works of art and historical artifacts, said Davis, a [computer graphics](#) expert who has developed software for displaying the results on a monitor.

"Right now the quality of our prints is nowhere near what museums would need, but the basic idea of being able to capture all of that information in a print is absolutely of interest to them," Davis said. "It's not just a novelty. There are potential uses where people would want to take a picture and examine it later from different lighting angles."



The idea for the project emerged from a graduate course Davis was teaching, but he said it wouldn't have gone anywhere if he hadn't brought the idea to the HP researchers he was collaborating with on another project. "This is a great example of industry-university collaboration. We had the idea, but we didn't know how to make it work," Davis said.

The researchers at HP Laboratories, Tom Malzbender and Ramin Samadani, eventually teamed up with Douglas Dunn at 3M to develop the reflectance paper. At UCSC, Davis worked with two computer science graduate students, Steven Scher and Adam Crume, to write the software code for printing the reflectance functions. The team has published their results in a paper in ACM Transactions on Graphics and gave a presentation on August 6 at SIGGRAPH 2012, the 39th International Conference and Exhibition on Computer Graphics and Interactive Techniques in Los Angeles.

Provided by University of California - Santa Cruz

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