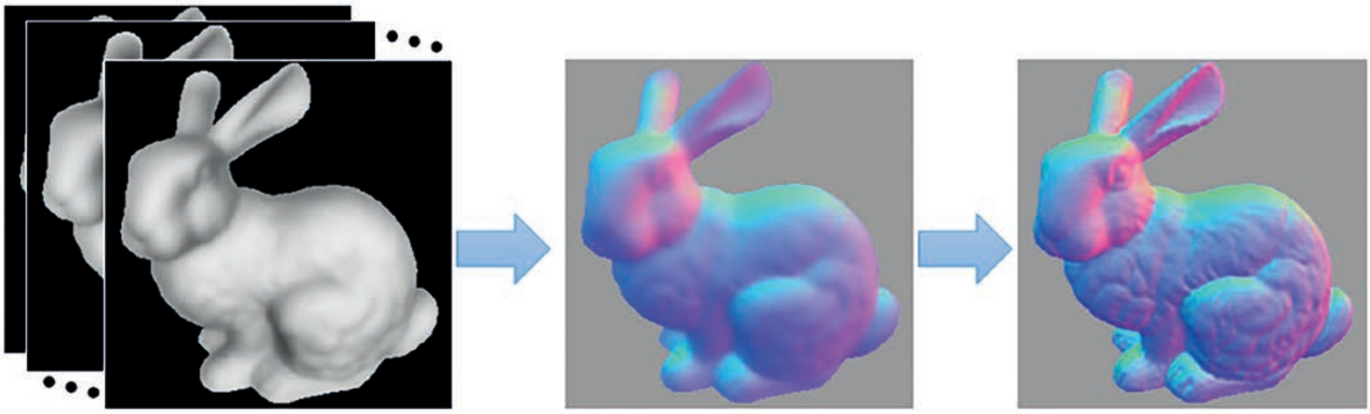
NAIST® Research Highlights

Nara Institute of Science and Technology | **Optical Media Interface Laboratory** www.naist.jp/en



A new technology makes it possible to turn multiple pictures of translucent objects (left panel) into sharp and realistic 3D images.

Visual computing

Resolving translucent 3D objects

Decoding light information with an innovative imaging technique can help robots better navigate their three-dimensional surroundings

Researchers from NAIST have developed a method to measure the three-dimensional (3D) shapes of everyday objects with translucent properties, such as food, clothing and dishes. The findings from Yasuhiro Mukaigawa and colleagues may make it simpler for robots to sense important environmental clues — the difference between a slippery bar of soap and a fragile vase, for example — that are critical for operating in real-life conditions.

Humans can determine if an object has a smooth or bumpy surface just by looking at it. But computers have a harder time making this judgment because of their reliance on flat, two-dimensional (2D) images. One way to overcome this problem is to illuminate an object and then capture images as the light source moves over it. This 'photometric stereo' technique deduces the surface normal vectors that project perpendicularly from each surface point by using the different shading angles seen in the images. Algorithms then turn the surface 'normals' into 3D reconstructions.

Photometric stereo has applications ranging from quality assurance to facial recognition. However, translucent materials are tricky to resolve with this technology: the random reflections of light inside such objects make it hard to relate shading patterns to surface geometry, and images appear blurry. To compensate, researchers have tried to develop models to remove sub-surface light scattering components from true surface shadings.

Implementing scattering models, however, requires a way to simultaneously inspect the material's optical properties along with its 3D shape. Mukaigawa and his co-workers solved this problem by recording how a thin ray of light reflects off a diffuse, uniformly scattering surface before projecting the beam over the translucent target. Separating the incident light radiance from the photometric stereo measurements using computer algorithms revealed the target's 'convolution kernel' — a mathematical image processing unit that holds information about surface geometry and sub-surface scattering.

Using a straightforward setup — a standard digital SLR camera, light projector and polarizers — the researchers examined intricate figurines carved from substances such as soap and marble (see figure). Their approach generated true-to-life 3D images that are remarkably sharper than conventional photometric stereo pictures of translucent objects. Mukaigawa notes that the simplicity and speed of this method could lead to improved types of computer vision technologies in the future.

"Many objects in our environment are translucent, but even expensive commercial sensors cannot measure their 3D shapes," he says. "If vision systems can know these shapes with our simple equipment, robots have a better chance of working in our living environment."

Reference

1. Inoshita, C., Mukaigawa, Y., Matsushita, Y. & Yagi, Y. Surface normal deconvolution: photometric stereo for optically thick translucent objects. In *Lecture Notes in Computer Science* Volume 8690, 2014, pp 346-359.

More information about the group's research can be found at the Mukaigawa Lab webpage:
http://omilab.naist.jp/