Engineers build a high-speed projector with visible and infrared capabilities

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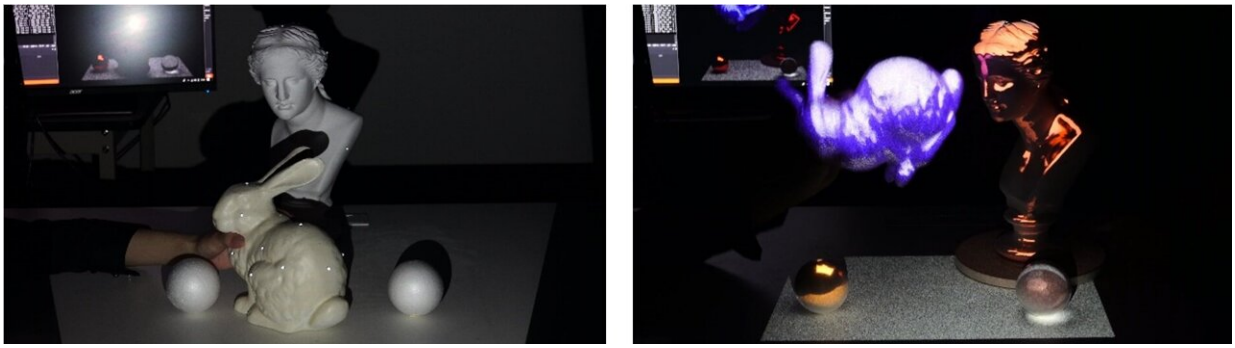

Figure 1. Recently developed projection mapping techniques can achieve a very realistic appearance, even in dynamic scenes. However, they suffer from critical limitations, such as the need for markers on moving projection targets. In the above photographs, the markers can be clearly seen on the bunny. Credit: Yoshihiro Watanabe from Tokyo Tech

An international business–academia collaboration has yielded a new type of projector that can project RGB and invisible infrared images simultaneously and independently at a high speed of almost 1,000 fps. With its high image alignment accuracy enabled by a custom optics engine, this projector integrates invisible sensing and visible display for a wide range of novel applications, such as dynamic projection mapping.

Recent progress in display and projection technologies is unlocking new ways to perceive and interact with digital media. Modern projectors and

related techniques, such as projection mapping, can visually augment surfaces, opening up possibilities for amusement attractions, concerts, stages, digital signage, task assistance and more. In many of these applications, the projection target is not limited to a flat, static screen; the projected image can be controlled in real time to match the surface of complex moving targets and make their augmented appearance more convincing.

Such techniques are referred to as dynamic projection mapping (DPM). They rely on visual sensing methods to detect the target surface and require high-speed sensing and high projection frame rate to properly merge the projected image and its target without noticeable misalignment. Unfortunately, conventional DPM has limited uses because it either needs markers attached to the target or has to be restricted to a single plane (Figure 1) to meet the high speed requirements.

On the other hand, projectors have also played important roles in visual sensing applications; projector-camera systems that project a reference image onto the target surface and then capture it can efficiently acquire spatial information without using markers. Nevertheless, this type of sensing has not been used for DPM because no existing device can handle display and sensing simultaneously with high performance and without interference.

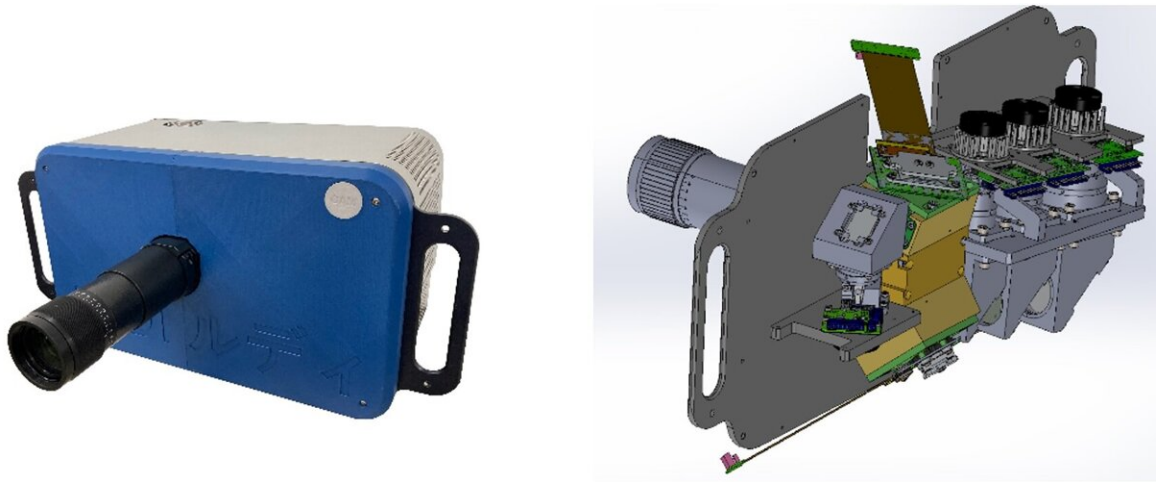

Figure 2. The developed projector has a unique optics engine (shown on the right) and two digital micromirror devices that enable it to project RGB and IR images with excellent alignment accuracy. Credit: Yoshihiro Watanabe from Tokyo Tech and the source and copyright of ITE and SID

The new type of projector is the result of an international business -academia collaboration led by Associate Professor Yoshihiro Watanabe at Tokyo Institute of Technology (Tokyo Tech), Takeshi Yuasa at Tokyo Electron Device Limited, Uwe Lippmann at Fraunhofer Institute for Applied Optics and Precision Engineering, and Petra Aswendt at ViALUX GmbH. This projector can simultaneously project visible RGB and invisible infrared (IR) images at a high frame rate of 925 fps. "Using our projector, we can construct a system that can sense its target surface using invisible wavelengths based on a projector–camera configuration which is a long-established computer-vision technology," explains Dr. Watanabe, "At the same time, the system can adaptively manipulate the images to display in visible wavelengths based on its sensing results."

At the core of this projector (Figure 2) lie two DLP (digital light processing) micromirror devices, which can handle 24-bit RBG and 8-bit

IR images simultaneously and independently (Figure 3). The team also developed a novel optical engine to align the images coaxially with excellent precision while allowing for a compact configuration capable of high-power projection.

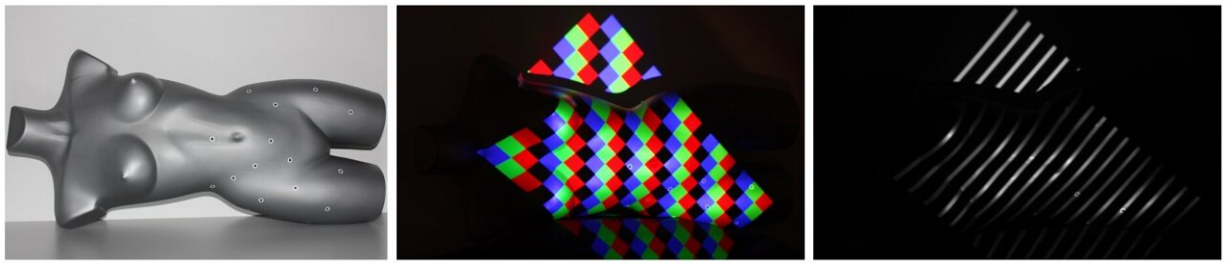

Figure 3. The developed projector can project different RGB and IR images as required, as shown in the pictures above. Keep in mind that the IR image shown on the right picture is normally invisible to the human eye. Credit: Yoshihiro Watanabe from Tokyo Tech and the source and copyright of ITE and SID

As a first application case, the team plans to introduce their novel projector for a new type of DPM system, which will be capable of manipulating the appearance of the entire scene based on the sensed shape without markers. "Conventional DPM approaches are limited in that they can only augment the appearance of targets with markers," says Dr. Watanabe. "The new type of mapping enabled by our projector will hopefully extend the fields of application of DPM."

Moreover, while only IR projection will be used for shape sensing in their first project, a projector-camera configuration using the entire system could be designed to acquire deeper spatial and physical information, thereby greatly enhancing projection mapping.

More information: High-Speed RGB+IR Projector based on Coaxial Optical Design with Two Digital Mirror Devices, The 28th International Display Workshops, 2021.

Provided by Tokyo Institute of Technology