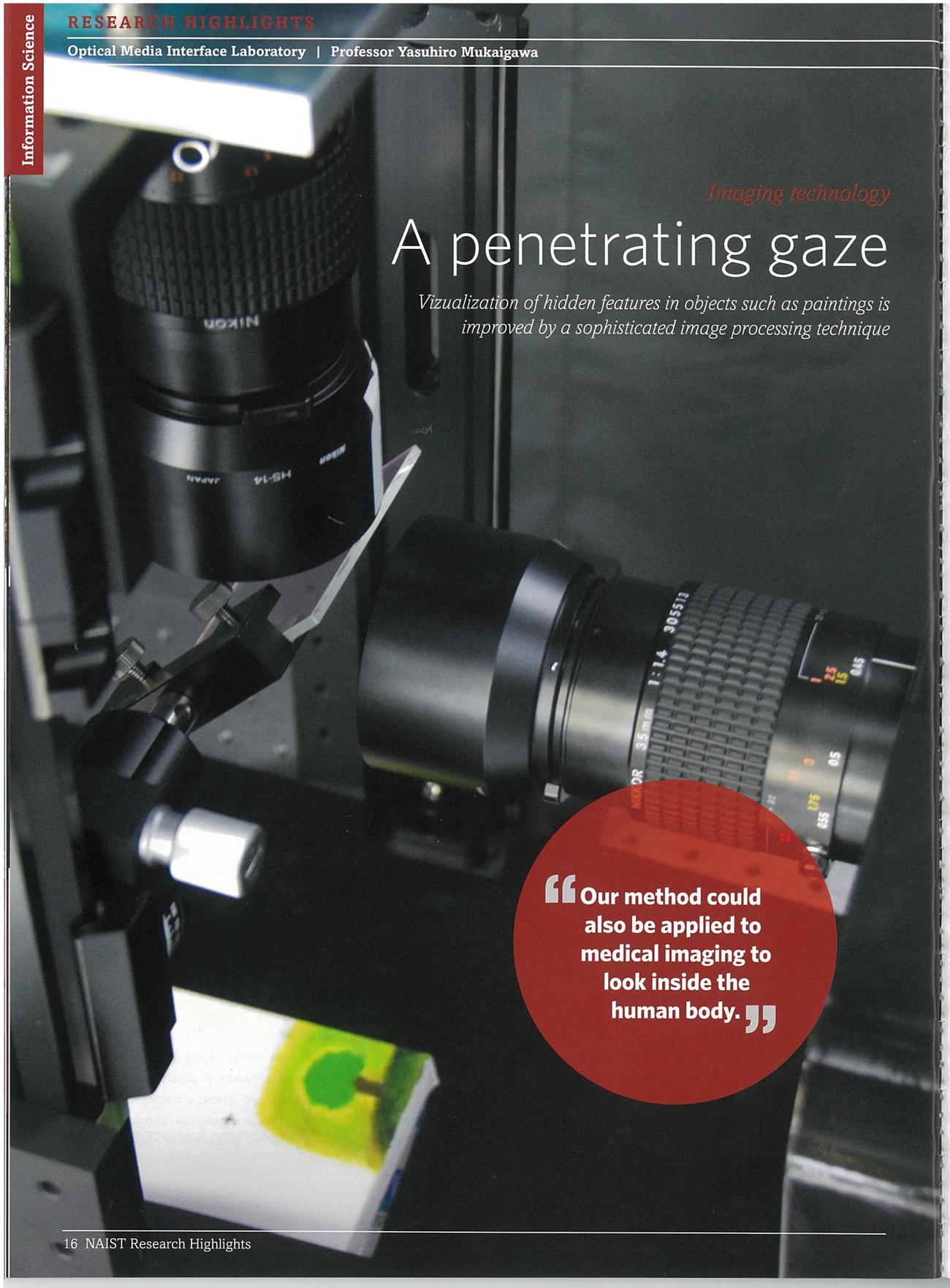
RESEARCH HIGHLIGHTS

Optical Media Interface Laboratory | Professor Yasuhiro Mukaigawa

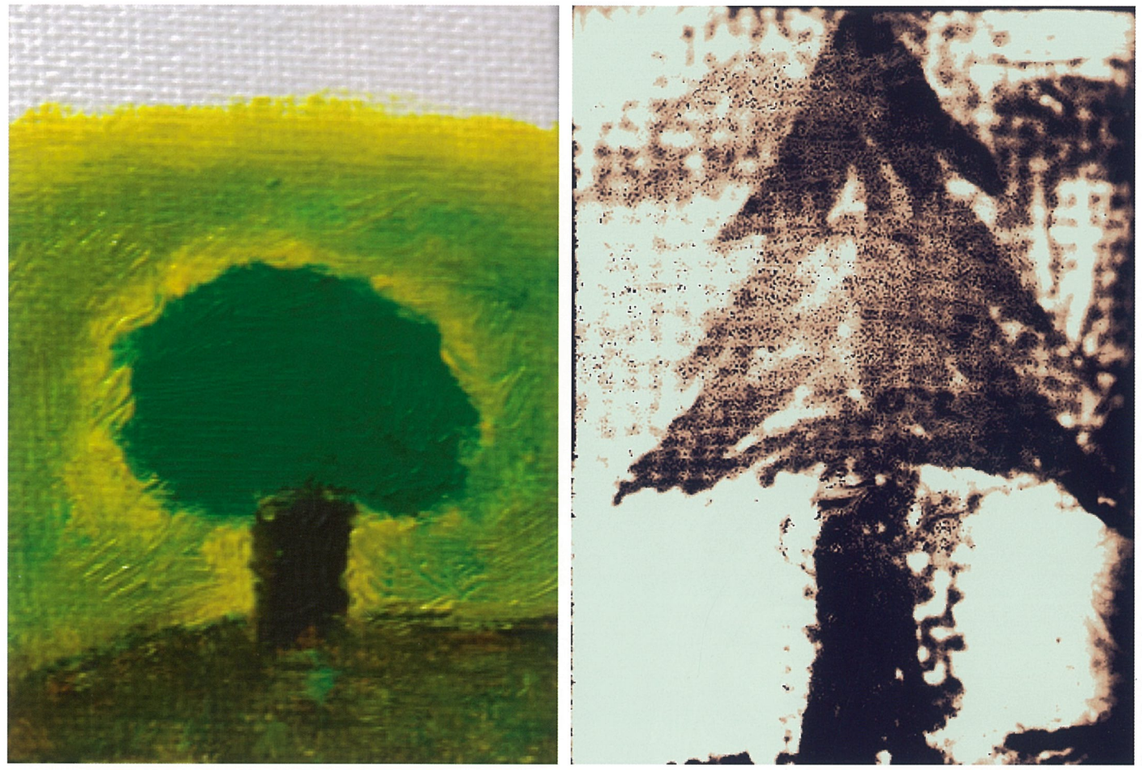
Imaging technology

A penetrating gaze

Vizualization of hidden features in objects such as paintings is improved by a sophisticated image processing technique



“Our method could also be applied to medical imaging to look inside the human body.”



Multi-frequency illumination can reveal hidden internal features of materials and objects, such as earlier artworks (right) that have been painted over (left).

Recently developed techniques such as X-ray fluorescence (XRF) and infrared reflectography (IRR) have given researchers a previously unimagined ability to look below the surface of paintings and other objects. They have, for example, found lost, obscured art, forgotten artists’ signatures and multiple layers of paint beneath famous works of art such as the *Mona Lisa*.

Now, NAIST researchers have developed a non-contact method that allows them to see through the surface of translucent objects to visualize hidden layers[1]. Their technique makes it possible to sequentially unveil the history of objects such as paintings without the potential damaging effect of XRF and with more clarity than IRR. This next-evolution of depth-penetrating visualization has been developed by Yasuhiro Mukaigawa, who heads NAIST’s Optical Media Interface Laboratory, Osaka University’s Kenichiro Tanaka and colleagues.

“The structure inside a translucent object is often invisible due to overlying material. However, by removing the light-scattering effect of the upper layers, we can visualize a clear image of the internal structure,” Mukaigawa explains. “The problem is, the appearance we normally observe is the visual ‘sum’ of all internal layers, and separating these layers as images is usually impossible.”

The team began with a theoretical analysis of the problem. As light penetrates a material, it is progressively scattered by the matter until it can penetrate no deeper. This scattered light can then re-emerge from the surface, but is re-scattered on its way back out.

The researchers modelled this process as a series of depth-dependent ‘point spread functions’, and in doing so realized they could recover the deeper images by illuminating the material with a checkerboard pattern and processing the obtained images.

“We project a checkerboard pattern on to the material and scan the pattern pitch from small to large,” Mukaigawa says. “We can then separate the internal layers corresponding to each pitch using some slightly complicated, but straightforward, computation.”

The researchers used their ‘multi-frequency illumination’ technique to reveal with remarkable clarity hidden paintings and even the signed name of an artist whose work had been painted over.

This imaging technique also forms the basis for a document-scanning system that can filter out the appearance of the wrong side when scanning double-sided prints. Historical artwork and archiving, however, are not the only potential application of this technique. “Our method could also be applied to medical imaging to look inside the human body,” Mukaigawa says.

Reference

1. Tanaka, K., Mukaigawa, Y., Kubo, H., Matsushita, Y. & Yagi, Y. Recovering inner slices of translucent objects by multi-frequency illumination. *Proceedings 28th IEEE Conference on Computer Vision and Pattern Recognition* 5464–5472 (2015).

More information about the group's research can be found at http://isw3.naist.jp/Contents/Research/mi-06-en.html
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