

New nondestructive broadband imager is the next step toward advanced technology

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New Unmanned Imagers for a Ubiquitous Sensing Platform

Non-destructive imaging and sensing has various industrial applications

- Quality control of materials
- Safety inspections
- Damage detection
- Medical imaging

There is an increased demand for multifunctional sensing devices that are flexible, portable, unmanned, and compatible with ubiquitous sensing platforms

Robot-assisted multi-axis movable photo-thermoelectric (PTE) monitor arm with built-in photo-source and imager

Flexible carbon nanotube (CNT) based broadband PTE imager	Portable freeform sensing module	Movable PTE monitor arm unit
<ul style="list-style-type: none"> Multi-view stereoscopic sensing Switchable reflective and transmissive modes 	<ul style="list-style-type: none"> Built-in miniature photo sources 360°- omnidirectional view 	<ul style="list-style-type: none"> Robot-assisted Multi-axis

Remote, non-destructive photo-monitoring of a defective miniature aerial winding road-bridge

Applications in the development of ubiquitous sensing platforms for photo-monitoring solutions in

Industries

Construction

Agriculture

AI

Robot-assisted, source-camera-coupled multi-view broadband imagers for ubiquitous sensing platform
 Li et al. (2021) | 10.1038/s41467-021-23089-w
 Nature Communications

The robot-assisted photo-source and imager built-in multi-axis movable PTE monitor arm, which represents a consolidation of functionality, led to the non-destructive unmanned remote high-speed omnidirectional photo-monitoring of a miniature aerial defective winding road-bridge. Credit: Tokyo Tech

One of the key aspects of academic and industrial research today is non-destructive imaging, a technique in which an object or sample is imaged (using light) without causing any damage to it. Often, such imaging

techniques are crucial to ensuring safety and quality of industrial products, subsequently leading to growing demands for high-performance imaging of objects with arbitrary structures and locations.

On one hand, there has been tremendous advancements in the scope of non-destructive imaging regarding the region of electromagnetic (EM) spectrum it can access, which now ranges from [visible light](#) to as far as millimeter waves! On the other, imaging devices have become flexible and wearable, enabling stereoscopic (3D) visualization of both plane and curved samples without forming a blind spot.

Despite progress, however, issues such as portability of sensing modules, the bulkiness of cooling equipment, device operation, and unmanned or robot-assisted photo monitoring remain to be addressed. "The transition from manned to robotic inspection can make operations such as disconnection testing of power-transmission lines and exploring cramped environments safer and more sustainable," explains Prof. Yukio Kawano, from Tokyo Tech and Chuo University, who researches extensively on terahertz (THz) waves (EM waves with frequency in the terahertz range) and THz imaging.

While multiple studies in the past have explored systems equipped with one of these modules, their functional integration has not yet been attempted, limiting progress. Against this backdrop, in a recent study published in *Nature Communications*, Prof. Kawano and his colleagues from Tokyo Tech, Japan, developed a robot-assisted, broadband (using a wide range of frequencies) photo-monitoring platform equipped with a [light source](#) and imager that can operate in a location-independent manner and switch between reflective and transmissive sensing.

In their proposed module, the scientists made use of physically and chemically enriched [carbon nanotube](#) (CNT) thin films to act as uncooled imager sheets that employed the photothermoelectric effect to

convert light into electric signals via thermoelectric conversion. Due to their excellent absorption properties over a wide range of wavelengths, CNTs showed a broadband sensitivity. Moreover, the imager sheet allowed for a stereoscopic sensing operation in both reflective and transmissive modes, thereby enabling inspections of several curved objects such as beverage bottles, water pipes, and gas pipes. By detecting the local changes on signals, scientists were able to identify minuscule defects in these structures otherwise invisible. Further, by employing multi-frequency photo-monitoring, ranging between THz and infrared (IR) bands, the scientists were able to extract both the outer surface and inner surface features using IR and THz light, respectively.

Finally, they achieved 360-degree photo monitoring using a light-source-integrated compact sensing module and implemented it in a multi-axis, robot-assisted movable arm that performed a high-speed photo-monitoring of a defective miniature model of a winding road bridge.

The results have spurred scientists to consider the future prospects of their device. "Our efforts can potentially provide a roadmap for the realization of a ubiquitous sensing platform. Additionally, the concept of this study could be used for a sustainable, long-term operable, and user-friendly Internet of Things system of a sensor network," says Prof. Kawano.

More information: Kou Li et al, Robot-assisted, source-camera-coupled multi-view broadband imagers for ubiquitous sensing platform, *Nature Communications* (2021). [DOI: 10.1038/s41467-021-23089-w](https://doi.org/10.1038/s41467-021-23089-w)

Provided by Tokyo Institute of Technology

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