The Beginnings of a New Phase in Medical Imaging?

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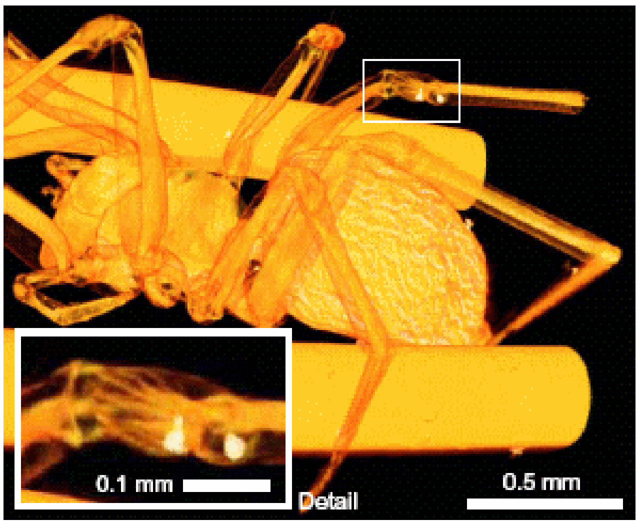

In a development that could help usher in a new kind of medical imaging for clinics and hospitals, researchers have demonstrated a practical x-ray device that provides 2- and 3-dimensional images of soft biological tissue with details that are ordinarily hard to discern with conventional x-ray imaging.

Image: A new demonstration of x-ray phase-based imaging yielded a picture of a small spider, with details of internal soft tissue that are hard to capture with any other imaging technique.

Performed by researchers at the Paul Scherrer Institut in Switzerland and the European Synchrotron Radiation Facility in France, this work may help make practical new medical applications, such as the ability to detect cancerous breast tissue directly, rather than the hard-tissue calcifications that are produced in later stages of the disease. The new x-ray demonstration appears in the 8 August issue of Optics Express, an open-access journal published by the Optical Society of America.

X-rays excel at imaging hard tissue—such as teeth—as well as the differences between hard and soft tissue—such as bones and skin in the human hand. However, x-rays are not good at distinguishing between different types of soft tissue, such as normal and cancerous cells in the breast. While x-ray mammography detects the hard "calcifications" that are the byproducts of breast tumors, researchers wish to be able to detect the tumor cells directly—potentially leading to better and earlier diagnosis of breast cancer.

This is just one of the potential biomedical applications of an emerging technique called phase-sensitive x-ray imaging. Normal x-ray pictures, such as those at dental offices, are "absorption-based" images: they rely upon the fact that the teeth absorb many more x-rays than the rest of the mouth. However, soft tissue does not absorb x-rays very well, making absorption imaging unsuited to the task of capturing the details of soft structures in such organs as the breast and kidney.

Optics researchers have long known that x-rays have the potential to make detailed images of soft biological tissue through a technique known as "phase" imaging. X-rays, a form of electromagnetic wave like light, can be visualized as a series of peaks and valleys like a water wave. When an x-ray encounters the boundary of two types of material, such as normal tissue and cancerous tissue, it will undergo a "phase shift": the peak of the wave will move backward by a small amount relative to the position where it would be if there were no sample in the beam. By measuring the phase shifts as x-rays pass through the boundaries of different kinds of tissue, researchers can obtain detailed pictures of soft biological tissue.

In a demonstration that could bring this approach much closer to medical applications, a new phase-based imaging device combines three desirable attributes—compact size (only a few centimeters in length), large field of view (up to 20x20 cm 2), and the ability to use x-rays over a broad spectrum of energies. Crucially, the design uses a pair of gratings—each a thin slab of material with narrow, closely spaced parallel lines etched deeply into them, like little slits carved into the inch marks of a ruler.

In the setup, a stream of x-rays passes through the object to be imaged and it undergoes a series of phase shifts, which distorts the stream in a precise way. The distorted x-ray stream then passes through the first grating and is diffracted; the grating slices the x-ray stream into multiple waves that combine and interfere to produce a series of fringes (bright and dark stripes). The second grating extracts from this pattern precise information on the inner details of the object (see accompanying article for more information).

Using this technique, the researchers imaged a small spider, revealing internal structures that would be difficult to image with any other method. The researchers believe that the modest requirements of this technique, both in terms of x-ray source, laboratory space, and materials, may make phase-based imaging practical for a wide range of biological and medical applications.

Source: Optical Society of America

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