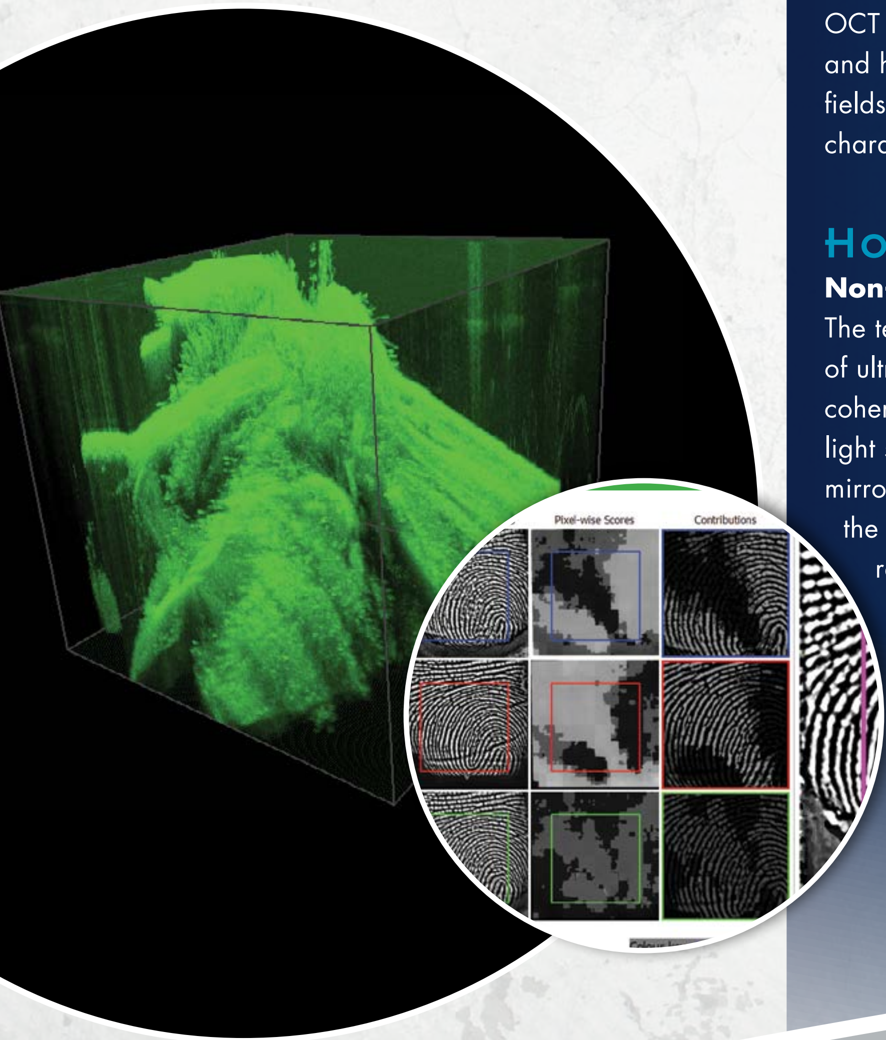
Focus on CSIR research

Laser technology for biometric and biomedical applications

Optical coherence tomography (OCT) is a non-invasive, non-contact imaging technique, capable of yielding both surface and sub-surface morphology (in 2D and 3D). High-speed, high-precision OCT systems employ lasers as the optical source. In addition to numerous applications in the biomedical imaging field, OCT can also be used for biometric acquisition and be a useful tool in the safety and security industries as well.



Raising the bar for fingerprint diagnostics

As part of a Department of Science and Technology-funded project, the CSIR has developed a high-speed, large-area OCT system for fingerprint biometrics. The OCT system is capable of acquiring both external and internal fingerprints, thus enhancing fingerprint acquisition and providing fake detection.

Researchers have demonstrated the ability to acquire live and latent (forensic) fingerprints using the system. Light-based techniques are popular in different spheres of diagnostic and therapeutic applications due to their non-invasive, non-contact properties. The OCT technique was first reported by Huang in 1991 and has since made significant strides in different fields such as dermatology, ophthalmology, polymer characterisation and biometrics.

How it works

Non-contact optical sensing technology

The technique is considered the optical analogue of ultrasound and works on the principle of low coherence interferometry. A broadband or tuneable light source is split between a sample and a reference mirror (reference path). When the difference between the distance travelled for the light, sample and the reference path is within the coherence length of the light, then interference will occur at the detector. This then generates an image after processing the resultant interference signal. OCT measures the echo time delay and intensity of backscattered light.

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Unlike conventional microscopy, the depth and lateral resolution are separated. The depth (axial) resolution is dependent on the spectral bandwidth of the light source, the broader the bandwidth, the lower the coherence length and the higher the depth resolution. The lateral resolution depends on the optics used.

Different configurations

All configurations of OCT are based on the same principle. These configurations are Time Domain OCT and Fourier Domain OCT. The former involves scanning the reference mirror back and forth to match different depths in the sample to within the coherence length of the light source. Fourier Domain OCT uses a fixed reference mirror and measures the spectral response of the resultant interferogram. The interferogram is encoded in optical frequency space and undergoes a Fourier transform to yield the reflectivity profile of the sample. Fourier Domain can be further divided into Spectral Domain OCT and Swept Source OCT.

Spectral Domain requires a broadband light source for illumination and separates the spectral components with a spectrometer. Swept Source uses a light source which probes the sample with different optical frequencies sequentially. The power is then measured with a single photo detector.

Wavelengths

The OCT systems operate at different wavelengths (depending on the application) either in the infrared (800-900 nm) or in the near infrared (NIR) band (1250–1350 nm). The NIR wavelengths are preferable when imaging non-transparent tissue due to the better penetration depth. Ophthalmology is performed at 800-850 nm due to the transparent nature of the eye in this band. High-resolution applications require shorter wavelengths. Longer wavelengths are considered for samples with higher scattering properties.

Many applications

The type of OCT system employed can be a simple, cost-effective solution or a complex, highly specific and fast system depending on the application. The CSIR's OCT system is not limited to this one application. The system can image a large surface area (25 by 25 mm) to a depth of 11 mm (sample dependant). Resultant 3D images (512 x 512 x 2048 pixels; XYZ) are acquired in less than three seconds. The heart of the system is a 200 kHz swept laser source and two-axis galvanometer-based scanner. Signal acquisition is made possible through a high-speed analogue-to-digital converter capable of speeds greater than 1GS/s.

> **Due to the contactless nature of OCT, this technology can acquire latent fingerprints without destroying potential useful DNA material for forensics thus allowing multiple uses for one piece of evidence. The 3D capability of OCT also means it can be used to get both the internal and external fingerprints of a person thus protecting against fake fingerprints. It also has the ability to detect sweat glands and thus detect liveness. These are important features that enhance biometric security features for high end applications such as military, national security points, forensics.**

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Optical coherence tomography

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