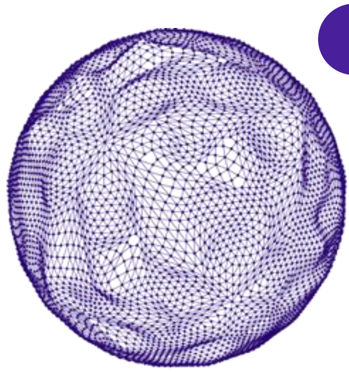
ATTRACT phase 2

Developing breakthrough technologies
for science and society



Light’s invisible properties can be used to detect cancer*

The authors of this article, together with colleagues in Finland and Denmark, are attempting to improve cancer diagnostics by exploiting the invisible properties of light, supported by artificial intelligence. Stock photo: Shutterstock.

Machines are currently learning how to identify cancer cells with the help of manipulated light. This approach may help to take the pressure off our hard-pressed health services and reduce waiting times for anxious patients.

According to the Norwegian Cancer Society, the results of tissue biopsies, which carry the information about the presence or absence of cancer, normally take between three to four weeks to come through. This is among the most difficult waiting times that we ever experience. However, in a few years' time, this waiting will be a thing of the past, thanks to new light-based technology and computers equipped with artificial intelligence.

Long waiting times

Today, much of diagnostics relies on a resource in short supply – specialists who undertake manual examinations of either the patient or tissue samples. This is why waiting times are often so long. Weeks or months can seem like years when you feel there may be something wrong.

Many people seek help from the private sector, where waiting times are shorter, but the cost of treatment very high. If you live in a low-income country, you may have no access to diagnostics at all.

Light – combined with artificial intelligence

In response to this, we at SINTEF have joined forces with colleagues from the universities of Southern Denmark and Oulu in Finland and have succeeded in breaking new ground in this field. We are attempting to improve cancer diagnostics by utilising the invisible properties of light, combined with artificial intelligence.

Diagnostics is about more than just chemistry (blood test analyses), electrical signals (ECG), ultrasound and X-ray radiographs. The very same sunlight that warms us on a summer's day can, when reflected from our tissues, tell us a lot about our health.

A simple example are the bruises we get after a fall. Our skin changes colour and this is easy to see. In order to diagnose cancer, on the other hand, tissue samples have to be treated chemically (stained) to colour them before their biological characteristics can be studied. Only then is it possible for a specialist, using a microscope, to see whether cancer has developed in the tissue.

However, the reflected light from tissue samples also contains information that our eyes cannot see. A lot of research is currently being carried out to evaluate exactly what the invisible properties of light reflected from our skin, eyes, and indeed the brain, can tell us about our health.

Oscillating in all directions

Some of this invisible information is contained in the way the light oscillates. While ocean waves move the seawater up and down, light waves oscillate in all directions – sideways and obliquely as well. We can see something of this oscillation when we send waves along a skipping rope.

But our eyes cannot distinguish between all the multiple oscillation directions contained in what we call 'polarised' light. However, this is exactly what we are focusing on. The light that we are studying can be compared to the journey of a ray of sunlight on its way to planet Earth.

Sunlight changes its oscillation direction, or polarisation, when it becomes scattered by small molecules or particles in the Earth's atmosphere. It is this scattering that makes the sky look blue (Rayleigh scattering). However, when the light encounters larger particles, such as the water droplets in mist, the colour becomes more diffuse when viewed from a distance. This is called Mie scattering.

Light is scattered in the cells of our bodies in the same way.

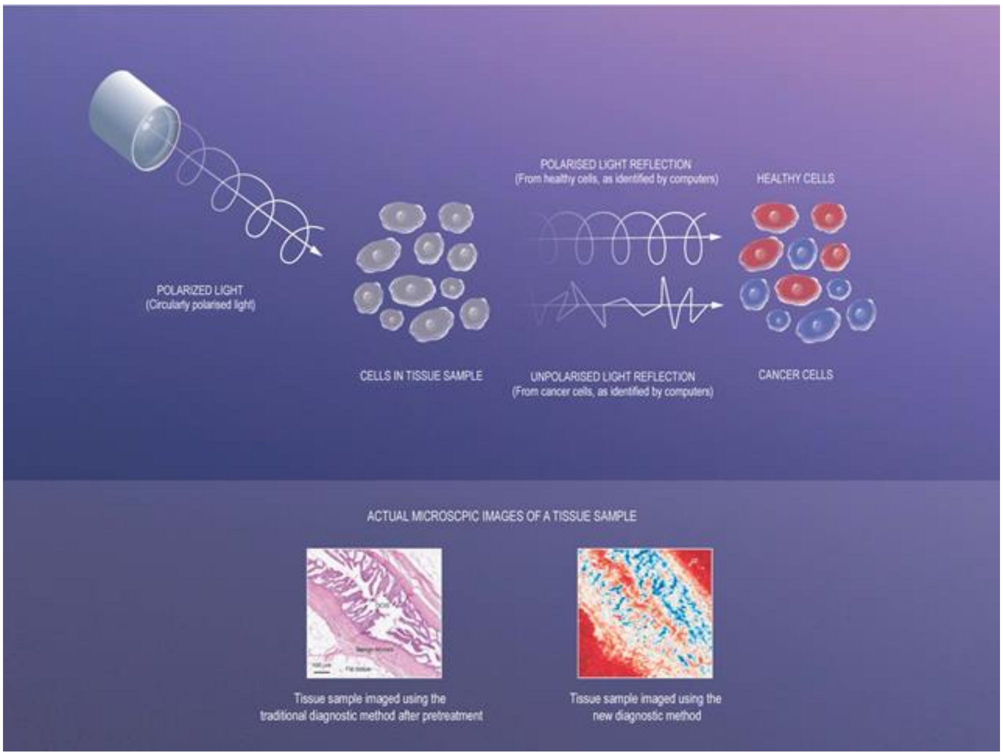


Illustration: Knut Gangåssæter/SINTEF/University of Oulu

This is how the invisible properties of light are used to reveal cancer cells in tissue samples:

Upper part of the figure:

- Cells are irradiated with circularly polarised light in which the oscillation direction assumes a spiral form.
- Normal cells will only influence the oscillation direction of the reflected light to a small extent.
- Cancer cells, on the other hand, will for the most part reflect unpolarised light (the polarisation direction becomes chaotic).
- This is how the machine learning algorithms are able to distinguish between normal cells (in red) and cancer cells (in blue).

Lower part of the figure (two microscope images):

- Images such as the one on the left are used by pathologists to determine the presence or absence of cancer using current diagnostic methods. Today, such tissue samples are pretreated before being examined by pathologists.
- The image on the right is the same sample analysed using a time-saving, automated method currently being developed by Scandinavian researchers. The blue areas show unpolarised light and thus indicate the presence of cancer cells.

Opportunities for more rapid cancer diagnoses

In simple terms, we obtain Rayleigh scattering from light that encounters the cores of healthy cells, but for the most part Mie scattering from the cores of cancer cells. Automation of the measurement of reflected light from tissue samples thus offers us the opportunity to perform more rapid cancer diagnoses.

This requires that we utilise all the information that the light has to offer. However, obtaining detailed information about the polarisation of reflected light in every pixel rapidly involves a volume of data that is much too large, even for highly trained specialists.

Computers, on the other hand, are able to deal with such large volumes of data. The application of machine learning, which is a branch of artificial intelligence, enables computers to see patterns that we cannot. So, by combining large volumes of data, analysed by machine learning, we will hopefully be able to make more accurate diagnoses.

Boosting successful diagnoses

For some this may sound like pie in the sky, but machines are beginning to make their mark in the field of medical diagnostics.

A study published by Google Research in the USA revealed that 92 per cent of the tumours presented in a selection of standard microscope images of tissue samples were correctly diagnosed by artificial intelligence, whereas only 73 per cent were identified by pathologists.

We believe that the success rate exhibited by artificial intelligence can be increased further with the application of new, light-based assessment methods, such as those involving the inclusion of measurements of changes in oscillation direction as light enters the tissue.

Rapid and sensitive instrument

A collaborative European research project headed by SINTEF is currently addressing this issue. We are developing a compact, rapid and sensitive instrument designed to examine tissue samples using polarised light with the aim of using machine learning to determine the presence or absence of cancer.

The aim of the project is to develop equipment that hospital staff and general practitioners can use after some basic training. The entire system will be based on the use of ground-breaking nanoscale surfaces, also known as metasurfaces. These are measured in millionths of millimetres and exhibit three-dimensional ‘patterns’ in the form of blocks or cylindrical columns. This approach offers us new ways of controlling the polarisation of the light we use.

Microscopic movable surfaces

At SINTEF, together with our colleagues from the University of Southern Denmark, we have discovered new ways of making such surfaces movable. This enables us to change the polarisation of light during the process, and in doing so provide more information to the algorithms whose function it is to determine the presence of cancer in the tissue.

The project is building on a promising test system previously developed by our colleagues at the University of Oulu. The work is being carried out under contract for ATTRACT, which is a joint collaborative project involving leading European research organisations, including CERN, focusing of the development of epochal new technology.

We are hoping that this solution will provide us with a two-fold benefit. Firstly, a simple and rapid diagnostic tool that can be used by general practitioners, and secondly, an instrument that offers cancer examinations to people in low-income countries who currently have no access to a diagnostic process.

And all this thanks to the invisible properties of light.

This feature article was first published in the newspaper Aftenposten on 8 January 2023 and is reproduced here with the permission of the paper.

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* This article was originally published at the SINTEF website: https://www.sintef.no/en/latest-news/2023/lights-invisible-properties-can-be-used-to-detect-cancer/

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This project has received funding from the European Union's Horizon 2020 research and innovative programme under grant agreement No. 101004462