

# ATTRACT TWD Symposium: Trends, Wishes and Dreams in Detection and Imaging Technologies



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## Lighting up a photonic network inside a living body

So imagine this: An infrared LED pours light into a plastic fiber whose soft tip I press onto my skin, in a precise spot. As I increase the power, light couples into one of my veins. The long wavelength prevents excessive scattering and absorption, so light is actually guided into my body, slowly scattering into the surrounding living tissue. Some of the scattered infrared light leaves the body. It is not visible directly to the human eye, but I can easily capture the image using any silicon-based video camera. The image is slightly blurred, but, then again, not that much at all. As I look closely, I have a glimpse of a childhood moment, playing in the dark with my torchlight, seeing the outline of the bones in my hand as light pressed through the flesh and reached my eyes. But that was visible light passing through the hand. This is far different. Here it is IR light and it is not simply hitting the skin, it is coupled into it. Now, different tissues in the flesh reflect and scatter the IR light into many regular patterns. On a closer look, I can see inside the flesh. Literally. Actually, there are specific spots that are reflecting the IR light very, very effectively. These are constellations of metallic gold droplets placed according to specific patterns on my bones. These give the precise references to the image, allowing a quantitative imaging and even three-dimensional rendering of the bones in proximity of the illuminated flesh. Looking inside what appear to us as opaque or reflecting objects is an all-time dream. When the system is opaque mainly because of scattering of density fluctuations, adaptive optics can be harnessed to reconstruct an emitter. Unfortunately, exactly like looking at stars through the turbulent and fluctuating atmosphere with an adaptive telescope, the technique requires you to know already what shape you are looking for. If it is an illuminated point in the sky, that is fine. If you are aiming to see extended shapes inside flesh, well, that is a wholly different story. In turn, imagine this technique being used to tailor the intensity and phase profile of the light exiting from the plastic multimode fiber. Then one can tune the launch pattern to achieve optimal coupling into the vein, or even design where and how light is allowed to escape into the flesh. So, instead of using adaptive optics to reconstruct an emitting spot from a blurred blob, adaptive optics is used to deliver light, where no precognition of what is going to be observed is needed.

A different approach is to embed inside the opaque tissue specific tags and markers, fluorescent emitters, that bind to specific tissues and molecules to allow the localization and, in some case, the super-resolved imaging of features from the outside. Once again, what could be done using the body itself to funnel light to specific portions under study?

In a more general context, can the body or portions of it be used to route light, to modulate it, to detect it, to generate it? Can light be used to transfer information? for example, placing the tip of a finger onto a source and the tip of another finger onto a detector, can light pass through the body, in the process detecting and sensing?

Pioneering the field will require the development of innovative tissue compatible fiber tips, the study of waveguiding in the flesh, the study of imaging using tags, and the mapping in terms of an optical network of portions of the human body. On a side, there is one portion of the body that naturally guides and funnels light. This occurs in glial cells in the vertebrate eye, where basic tissue typical of the brain differentiates into perfectly functional waveguides. In fact, in the eye, it is these natural glial cells with their transparent elongated form that funnel light through the opaque mass of tissue that protects the photosensitive tissues.

### Summary

Seeing in real-time inside living tissue, using living tissue as an optical network, infrared imaging, plastic optical fibers, adaptive optics, fluorescence imaging, gold droplets.

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