Forschungsschwerpunkte – Professor Vasilis Ntziachristos

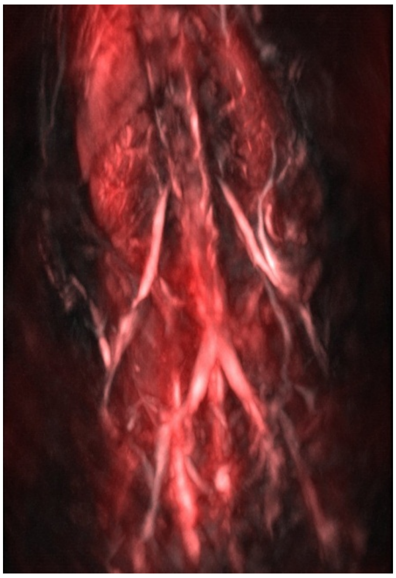
Prof. Vasilis Ntziachristos is a Professor of Medicine and Professor of Electrical Engineering and Chair of Biological Imaging (CBI) at the Technische Universität München (TUM) and the Director of the Institute for Biological and Medical Imaging (IBMI) at the Helmholtz Zentrum München (HMGU). He has been a pioneer of optical technologies and has risen to international acclaim through breakthrough developments in the fields of optical, optoacoustic and molecular imaging. His research focuses on the basic development and translation of innovative in-vivo imaging technology to the life sciences, for addressing unmet biological, drug discovery and clinical projects. Application areas include mesoscopic imaging for the biomedical laboratory and diagnostic, theranostic and disease monitoring approaches for major diseases including cancer, inflammation, cardiovascular and neurodegenerative disease.

One powerful driver of this research was Prof. Ntziachristos' belief that enhancing volumetric optical imaging *in-vivo*, i.e. non-invasive optical imaging of large tissue volumes, can accelerate basic and drug discovery and lead to better methods for advancing the quality of healthcare. To achieve this, his research team has focused on addressing the two major limitations of volumetric optical imaging: low resolution and contrast. Overcoming these two issues could deliver methods that enable tissue interrogations deeper than what is conventionally allowed by today's approaches and address limitations in the biological laboratory and in interventional clinical imaging. Today's microscopy methods only allow imaging of relatively superficial events and small fields of view. This limited performance has shaped entire segments of biology towards drawing conclusions on human development and disease by studying tissues of less than 1mm in size, typically ex-vivo, or by utilizing naturally transparent organisms such as very young fish. Deeper optical penetration could, however, allow the study of more complex, non-transparent tissues and larger volumes in order to gain a more complete picture of three dimensional biological events. Similarly, despite the technologically-rich medical environment, a large number of clinical-decision making in surgery and endoscopy is still based on human vision, i.e. using the human eye as the primary detector – a practice that has remained unchanged since the beginning of medicine. Human vision however cannot visualize under the tissue surface and it is not particularly sensitive to cancer cells and molecular markers of disease. For this reason surgical removal of disease or endoscopic detection comes with high miss rates.

Improving upon the resolution required the development of an imaging method based on the photoacoustic effect termed Multi-Spectral Opto-acoustic Tomography (MSOT). Prof. Ntziachristos put together a team of interdisciplinary skill, including mathematics, physics, engineering, biology and medicine. The result was an intricate method which listens to light being absorbed in tissue, i.e. it detects ultrasound waves generated in response to the absorption of transient light within tissue. By using illumination at multiple wavelengths and mathematical reconstruction and image analysis MSOT can resolve the spectra and therefore the distribution of different photo-absorbing molecules in tissue. Over several years of development and iterations the method has shown the ability to detect multiple photo-absorbing molecules at resolutions not available to other optical imaging methods. In contrast to conventional optical imaging methods MSOT penetrates through several millimetres to centimetres under the tissue surface with resolution ranging from a few tens to a few hundreds of microns, depending on the depth studied. This unprecedented performance has shown recently the ability to simultaneously visualize anatomical, haemodynamic and molecular function in various organs and diseases enabling novel insights into disease development and heterogeneity.

In addition to the developments in optical technology, advances in contrast generation are important to enhance the capacity of detecting disease with increased sensitivity and specificity. Parallel developments in this area have resulted in the first in-human clinical translation of targeted fluorescent agents to detect cancer during surgery. The premise is to administer an optical agent to humans which can specifically attach and track cancer cells or identify a particular physiological or molecular function of interest. Generation of optical contrast using agents that target cancer cells was shown clinically to significantly improve detection of disease over human vision. This development points to a paradigm shift in endoscopic and surgical disease detection from human vision to biomarker-based detection.

The Leibniz Prize comes at a highly timely manner whereby advanced MSOT imaging and contrast generation should be seamlessly combined to make the above advances appropriate for mainstream use in biology and medicine. This translation can only be achieved through innovative steps that allow integration and performance metrics appropriate for the dissemination of next-generation optical imaging in the life sciences with the ultimate goal of detecting disease more accurately and earlier. In addition to the great honour granted by the Leibniz Prize it is therefore a hope and a great motivation for the entire Ntziachristos team and its team members that are behind these seminal developments to give back to society by offering better ways to detect disease and guide therapy and see the translation of these technologies to medical environments.



Optoacoustic tomography allows for high-resolution imaging deep inside tissues, here visualizing the vasculature of the abdomen of a mouse.