Editorial

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Active imaging

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This special issue of *Advanced Optical Technologies* is dedicated to the broad field of active imaging. An active imaging system combines a very sensitive sensor with its own light source. This field of research was founded several decades ago with the invention of the laser, but the first mature systems have only been available, in laboratory and commercially, since the development of small and powerful lasers or laser diodes as well as very sensitive sensors.

Typically, active imaging systems are named after their main sensing approach that is light detection and ranging (LiDAR) or laser detection and ranging (LADAR). There are many forms of active imagers, like two-dimensional (2D) or three-dimensional (3D) LADAR, applying a scanning single or an array of many sensor elements. In past and current research, a lot of different sensing approaches were investigated to probe dedicated physical properties of surfaces within the scene by controlling the spatial and temporal illumination properties as well as the sensing modalities of the receiver side.

Today, with the development of new detectors, like single photon avalanche diode (SPAD) detectors, active imaging is facing a new revolution and is about to enter the era of computed imaging. For instance, by combining illumination with very short light pulses (ps- or fs-pulses) and sensors that can count single photons and measure the photon time-of-flight at the same time scale, we can expand optical sensing to scenes outside of the classical field-of-view. This enables new, unique and important options for civilian (automotive, medical, safety) and military applications.

Nowadays, practical applications of active imaging can be found in night vision, remote sensing, surveillance and reconnaissance, range and intensity imaging in outdoor scenarios as well as high-speed imaging techniques in laboratory experiments. This special issue of *Advanced Optical Technologies* can only cover a small part of the entire field of active imaging and reviews certain technologies and application cases.

In our list of contributions, we cover a historical overview as well as the development of new sensing approaches and sensor technologies. We present investigation of the impact of turbulence on the imaging quality and the mitigation of laser speckle through accumulating the optical intensities from many laser pulses. Furthermore, we present sensing operations in highly scattering environments such as underwater imaging applications.

In **'Sixty years of advanced imaging at the French-German Research Institute of Saint-Louis'**, Frank Christnacher et al. present a historic overview of active imaging technologies at their institute from the very beginning (founded in 1959) to very recent research activities. The article covers high-speed imaging with the Cranz-Schardin camera for investigations in aerodynamics and dynamic material tests, to holography, laser gated viewing and computational imaging.

Vasyl Molebny reviews various active imaging technologies in the article **'Nick-named laser radars'**. The manuscript presents the application of different laser radar technologies ranging from laser-microwave radar and coherent laser radar to wavefront sensing laser radar.

Experimental investigation of accumulating laser gated viewing at shortwave-infrared (SWIR) wavelengths is presented by Yves Lutz et al. in the article **'Experimental SWIR gated viewing in accumulation mode'**. The authors demonstrate that accumulating light from sequentially emitted laser pulses in a single image can significantly reduce the coherence of the laser illumination and thus illicit impact of laser speckle and atmospheric turbulence on the imaging process.

In **'InGaAs APD matrix sensors for SWIR gated viewing'**, Frank Rutz et al. present the development of a novel focal plane array for laser gated viewing at SWIR wavelengths. The avalanche photo diode (APD) matrix sensor was integrated and tested in a gated viewing system. The authors present some experimental results including laser gated viewing and range imaging.

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Further, the impact of atmosheric turbulence is discussed in the article **'Modelling and impact of the turbulence effect on flash and cumulative 2D active imaging system'** by Olivier Meyer. The author presents detailed simulation of imaging system performances due to the turbulence and compares accumulation and flash laser gated viewing technologies.

Finally, the application of active imaging in turbid environments is investigated in the article **'Laser-based imaging applications in turbid waters'** by Thomas Scholz et al. In this article, two different three-dimensional active imaging methods are compared in an underwater environment: laser oblique scanning (LOS) and laser gated viewing (LGV). While LOS can deliver very high point cloud densities, LGV has advantages in delivering live video feeds.

This collection of papers confirms very clearly that active imaging is still a fascinating and evolving imaging approach with various fields of application. Although this special issue cannot cover the whole field, we do hope that you, the reader, will share our enthusiasm for active imaging.

In closing, we would like to thank all authors for contributing to this special issue by writing these excellent articles and sharing their knowledge with a wider community. Further, we would like to thank the *Advanced Optical Technologies* team who contributed to this issue.

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Martin Laurenzis is with the French-German Research Institute of Saint-Louis (ISL) since 2004. He studied Physics at the University of Dortmund (Germany) and received his MSc degree in solid-state physics. After that, he did his PhD at the University of Aachen (Germany) in Electrical Engineering and Information Technologies in the field of rewritable optical data storage. At ISL, he is working on active imaging technologies for three-dimensional sensing and non-line-of-sight imaging around a corner.

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Frank Christnacher received his MSc degree in the field of solid-state physics in 1988 and his PhD in the field of optical data processing and pattern recognition in 1992, both from the University of Haute-Alsace (France). He is currently the head of the 'Advanced Visionics and Processing' group of the French-German Research Institute of Saint-Louis. Specialized in the area of night vision imaging systems and active imaging, he has initiated and led numerous international scientific collaborations.