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Editorial: Novel optical measurement and imaging technologies using broadband light sources

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Editorial on the Research Topic
Novel optical measurement and imaging technologies using broadband light sources

Optical measurement and imaging technologies have undergone rapid development in recent years, particularly with the integration of broadband light sources. These advances have expanded the reach of optical physics into diverse fields ranging from astronomy and industrial inspection to biomedical imaging, navigation, and environmental monitoring. By leveraging wide spectral bandwidths, researchers are achieving unprecedented levels of spatial resolution, phase sensitivity, robustness against noise, and speed of data acquisition. The Research Topic *"Novel Optical Measurement and Imaging Technologies using Broadband Light Sources"* brings together contributions that demonstrate both the theoretical underpinnings and practical implementations of such approaches, highlighting the richness of innovation in this area.

The motivation behind this Research Topic was to create a platform where scientists could present cutting-edge methodologies for precision measurement and imaging systems using broadband or structured light. Traditional single-wavelength optical systems often suffer from limited spatial resolution, narrow dynamic ranges, or susceptibility to environmental disturbances. By contrast, broadband illumination and hybrid optical designs open new opportunities for addressing challenges in large-scale astronomy, nanoscale biophysics, industrial monitoring, and defense-related sensing. Collectively, the contributions here advance both the accuracy of measurement and the scope of applications.

The published works span a wide range of applications and methods, yet all share the unifying theme of exploiting broadband optical strategies to enhance measurement robustness.

- Astronomical Metrology with Structured Light: Zhang et al. proposed an accuracy analysis framework for pose measurement of subreflectors in large-aperture antennas using stereo structured light. Their method combined error-in-variables modeling, Newton's downhill iteration, and Bursa transformation theory, enabling high-precision six-degree-of-freedom alignment within milliseconds. This work demonstrates how optical metrology ensures the reliability of deep-space communication and radio astronomy under challenging environmental conditions.
- Rapid 3D Reconstruction for Industrial Pipelines: Yao et al. introduced a monocular vision approach for reconstructing constant-diameter straight pipelines via single-view perspective projection. By eliminating the need for markers or end-face contours, the method achieved a near-100% improvement in reconstruction speed while maintaining accuracy. This advance offers significant benefits for inspection drones tasked with monitoring industrial infrastructure such as oil and gas pipelines.
- Lensless Digital Holography with Structured Illumination: Zheng et al. reported a structured illumination lensless digital holographic microscopy (SI-LDHM) technique. By combining multiple orientations and phase shifts, the method suppressed twin-image artifacts and improved spatial resolution by more than 15%. This innovation holds promise for quantitative phase imaging in biomedical and industrial contexts where high throughput and compact instrumentation are critical.
- External Ballistic Measurement under Blast Wave Interference: Duan et al. investigated the impact of muzzle blast waves on light-screen detectors in ballistic velocity measurements. Using ray tracing and Runge-Kutta numerical methods, they quantified radiation flux distortions induced by blast-induced refractive index changes. Their findings provide a foundation for improving the reliability of optical measurement systems in defense and security applications.
- Distributed Acoustic Sensing with Hybrid Interferometry: Yang et al. presented a novel φ-OTDR phase demodulation scheme that integrates a 3 × 3 coupler with a Sagnac interferometer. The approach improved spatial resolution and extended frequency response by mitigating path-imbalance noise, offering robust distributed sensing for vibration monitoring in civil infrastructure and geophysical exploration.
- Polarization Imaging in Marine Environments: Liu et al. demonstrated a multi-band polarization imaging and processing strategy for scenes obscured by sea fog. By combining multi-wavelength data through wavelet fusion, their approach enhanced contrast and edge details under low signal-to-noise conditions. This method provides valuable tools for navigation, maritime safety, and remote sensing in adverse weather.

Together, these contributions underscore the transformative potential of broadband light sources when coupled with novel optical designs and computational methods. The breadth of applications, from radio telescopes to marine navigation, illustrates how advances in one field can inspire solutions in another. Importantly, these studies highlight not only measurement accuracy and imaging fidelity but also robustness to environmental disturbances, compact system architectures, and computational efficiency. We hope that this Research Topic inspires further interdisciplinary research and accelerates the translation of optical innovations into real-world applications.

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