Holographic anniversaries: a tribute to holographic pioneers

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Abstract—This editorial presents shortly the holographic timeline and the most important holographic pioneers. This is the background to an overview of the contents of this special issue of the Photonics Letters of Poland, devoted mainly to digital holography. The published papers from international research groups present a wide range of approaches and applications, including metrology, displays, computer-generated holograms, and biomedicine.

This special issue of Photonics Letters of Poland is a tribute to the pioneers of holography (Fig.1) and the celebration of three significant anniversaries. **Hundred years ago (in 1920),** Polish scientist **Mieczysław Wolfke** published in Physikalische Zeitschrift the paper in which he proposed theoretically the concept of holography based on optical imaging theory. Wolfke's works were unfortunately forgotten for many years. After **Dennis Gabor**'s paper in 1948, in which he presented theoretically and experimentally the concept of holography and which led him to receiving **fifty years ago a Nobel Prize (in 1971)**, several important inventions which happened in the 1960s.

Sixty years ago, in 1962, Yuri **Nikolaevich Denisyuk** and **Emmett Leith & Juris Upatnieks** published their seminal papers on reflection holography and off-axis holography, respectively. Together with the invention of the laser (in 1960), these works had a substantial impact on making holography a much more practical and popular discipline. During the late sixties, Stephen Benton proposed rainbow holograms opening up the science of holography to artists and security applications. At the same time, **Adolf Lohmann** introduced computer-generated holograms where computers were used to numerically generate holograms to be printed and photographed for optical reconstruction. Finally, **Joseph W. Goodman** and **Leonid Yaroslavsky** proposed using an electronic recording of holograms, followed by numerical processing to reconstruct the object digitally. This invention had opened a new era of holography, namely digital holography.

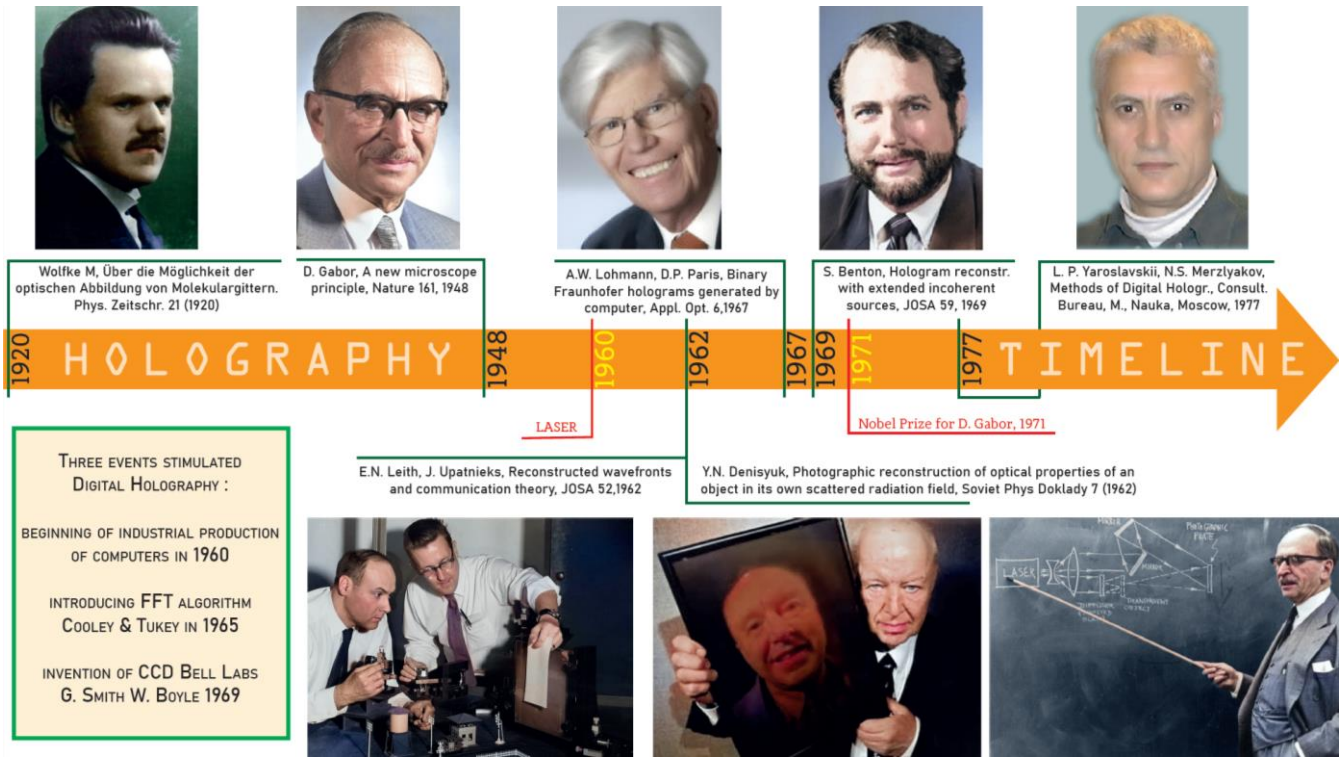

Fig. 1. Holography timeline: from optical to digital holography.

This special issue starts with the paper by Krzysztof Petelczyc, which describes the history of Wolfke's pioneering work on holography and tries to recreate the thought process that led to it. It is worth reminding that Dennis Gabor mentioned Mieczysław Wolfke as the person who proposed the principles of holography as early as 1920 (which Gabor did not know, independently making the same discovery).

The following papers are focused on various aspects and applications of digital holography and computer-generated holograms.

Ichirou Yamaguchi, the inventor of phase-shifting digital holography, reminds the readers of the principles and importance of this technique and introduces its further improvements applied to shape and deformation measurements.

Pascal Picard discusses recent advances in speckle decorrelation noise removal from phase data delivered by holographic interferometry. Two main topics are considered: modeling the decorrelation noise in digital Fresnel holography and a new approach to speckle de-noising using deep convolution neural networks.

Weijie Wu, Mike Pivnenko, and Daping Chu provide an overview of the applications of phase-only LCOS in two-dimensional (2D) digital holography, including the fundamental operating principle of phase-only LCOS SLMs and their hardware performance. They also discuss LCOSes potential improvements and applications for futuristic holographic displays.

The paper by Jędrzej Szpygiel, Maksymilian Chlipała, Rafał Kukołowicz, Moncy Idicula, and Tomasz Kozacki presents a distortion correction method enabling a distortion minimized, large size image in a wide-angle holographic projector, which is highly demanded by the display market. This technique applies numerical predistortion of an input image used for hologram generation. It is based on the estimation of distortion coefficients by comparing optically a reconstructed point test chart with its original.

The subsequent three papers are devoted to an improvement of computer hologram generation methods with specific functionalities. The joint paper by Michał Makowski and Tomoyoshi Shimobaba addresses the problem of limited efficiency of random-phase free computer-generated holograms in the case of high contrast binary images with dominant high spatial frequencies.

The paper by Mateusz Sadowski and Michał Makowski describes numerical optimization of the process of writing and reconstructing 2-D images in binary-phase computer-generated holograms stored in binary photo-magnetic materials. Such materials showed efficient and ultra-fast rewriting of holograms where the intensity of threshold allows for a dense, sub-diffraction limit packing of hologram points.

Mateusz Surma, Mateusz Kałuża, Patrycja Czerwińska, Paweł Komorowski, and Agnieszka Siemion present a new approach to designing diffractive optical elements (CGH) for THz radiation. The design utilizes a neural network-based algorithm, which can address the problem of small f-number values and is also suitable for complicated distributions.

Finally, the outstanding role of digital holographic microscopy in biomedical applications at cellular level is addressed in the paper by Arkadiusz Kuś, Wojciech Krauze, and Małgorzata Kujawińska. They present the history and outlook on the development of optical diffraction tomography with holographic projections and optical coherence tomography, two seemingly distant techniques that have recently been brought close together by a common theoretical model described by the common k-space theory. With this common ground, the authors expect a multitude of exciting new holography-tomography systems to appear in the next few years.

The presented papers are just a small sample of a great number of research works and commercial efforts related to holography field. With constant progress in novel materials, detectors, spatial light modulators, integrated photonics and computer power it is expected that holography, being the most versatile imaging and measurement method, will finally take the rightful place in multiple areas of our life.

