MAGNIFICATION-INVARIANT SURFACE PROFILING TECHNIQUE FOR STRUCTURED ILLUMINATION IMAGING AND MICROSCOPY

Significance

There has been tremendous advancement in the optical imaging field that led to the development of structured illumination microscopy with applications in various areas such as surface profiling and super resolution imaging among others. Currently, the working principle of structured illumination microscopy is based on the modulating the input illumination light to provide the depth information. Alternatively, recent research has shown that scanning the focal plane of the illuminated pattern enables determination of a three-dimensional surface profile of a specimen under investigation. Even though the process is precise and accurate, the axial scanning is susceptible to vibration distortion due to the long image acquisition time.

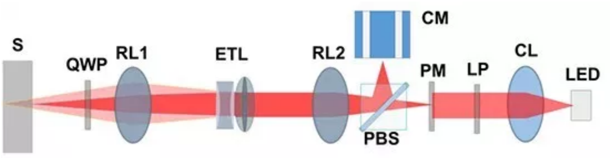
To this note, several techniques have been developed to solve the axial scanning method. For instance, remote focusing method even though developed to eliminate the moving parts cannot work without motion especially for moving the mirror in the image plane. In addition, in most of the optical imaging systems, the magnification change problem associated with depth scanning cannot be ignored and more so for those based on the electrically tunable lens.

Dr. Ju Wan Kim and Professor Byeong Ha Lee of Gwangju Institute of Science and Technology recently developed a structured illumination technique for effective surface profiling process, together with Dr. Jae Sung Ahn and Dr. Joo Beom Eom from the Korea Photonics Technology Institute. Fundamentally, they developed the structured illumination system based electrically tunable lens that was technically free from the ill effects resulting from the magnification changes in focal length and surface reflections of optics. Additionally, the authors validated their work by scanning an object plane without motion using the electrically tunable lens. Their work is currently published in the journal, *Optics Communications.*

In brief, the research team first explored the possibility of using a telecentric system to achieve a better performance of the magnification-invariant structured illumination system. This, however, depended on the geometric analysis which helped in minimizing the alignments errors involved. Next, the factors affecting the electrically tunable lens based structured illumination profiling and their remedies were experimentally investigated. Eventually, the effects associated with the strong reflection emanating from the lens surfaces were examined. The polarizing beam splitter and the quarter-wave plate were used to reduce the unwanted reflection. With this, the efficiency of using an electrically tunable lens was verified.

The authors observed that the developed imaging technique can effectively scan a three-dimensional object to obtain a surface profile image. Consequently, the obtained image was depth-resolved due to the fine structure of the pattern mask. On the other hand, incorporating the electrically tunable lens significantly enhanced the depth scanning speed while a 4-*f* relay optical system was utilized in minimizing the change in the magnification ratio. This was attributed to the good reproducibility and hysteresis properties of the electrically tunable lens.

In summary, the researchers developed a simpler and faster method based on electrically tunable lens. Interestingly, the object under imaging underwent no motion during the scanning. For instance, by keeping the magnification ratio change below 0.03, scanning depth variation of 35mm was successfully achieved. In general, the study will advance the structured illumination imaging technologies especially in cases that require high speed and rapid scans. This will further enhance their applications in various fields.



About the author

Dr. Ju Wan Kim is a postdoc of the Advanced Instrumentation Institute at Korea Research Institute of Standards and Science (KRISS). He received his B.S. degree in biomedical engineering from Chonbuk national university, Jeonju, Republic of Korea in 2009 and a Doctor of Philosophy in the department of biomedical science and engineering from Gwangju Institute of Science and Technology (GIST), Gwangju, Republic of Korea, in 2019. His research interest includes digital holographic microscopy, structured illumination microscopy, telecentric tunable imaging system and intraocular pressure measurement.

About the author

DR. Jae Sung Ahn is a senior researcher of Korea Photonics Technology Institute. He received his BS, MS and PhD degrees in physics from Seoul National University in 2006, 2008 and 2015, respectively. He is the author of 14 journal papers. His research interests are 3D optical microscopy, scanning probe microscopy and fluorescence lifetime imaging microscopy.

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Dr. Joo Beom Eom is a principal researcher at Korea Photonics Technology Institute. He received his BS degree in physics from Yeungnam University in 2000, and MS and PhD degrees in the field of information and communications from Gwangju Institute Science and Technology in 2002 and 2011, respectively. He is the author of 18 journal papers and has more than 50 patents. His current research interests include optical coherence tomography, photoacoustic imaging, spectroscopy, and terahertz imaging and spectroscopy.

About the author

Byeong Ha Lee received his B.S. and M.S. degrees in physics from the Seoul National University, Korea, in 1984 and 1989, respectively. At 1996, he obtained his Ph.D. degree in physics from the University of Colorado at Boulder, USA. After working as a STA fellow in the Osaka National Research Institute of Japan from 1997 to 1999, he joined the Gwangju Institute of Science and Technology (GIST), Korea, where he is currently serving as a full professor. From 2017 to 2018, he served as the director of the Advanced Photonics Research Institute (APRI), Korea.

Now he is working as a vice president of the Optical Society of Korea (OSK). His research interest includes fiber optic sensors, fiber distributed sensing, specialty fibers, optical coherence tomography, photoacoustic sensing and imaging, and various full-field 3-D imaging modalities.

Reference

Kim, J., Ahn, J., Eom, J., & Lee, B. (2019). **Magnification-invariant surface profiling technique for structured illumination imaging and microscopy.** Optics Communications, 434, 257-263.

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