Frontiers of Information Technology & Electronic Engineering
www.jzus.zju.edu.cn; engineering.cae.cn; www.springerlink.com
ISSN 2095-9184 (print); ISSN 2095-9230 (online)
E-mail: jzus@zju.edu.cn

Editorial:

Special feature on computational photography

Qiong-hai DAI
(*Tsinghua University, Beijing 100084, China*)
E-mail: daiqh@tsinghua.edu.cn

https://doi.org/10.1631/FITEE.1730000

Computational photography is an emerging field targeting for overcoming limitations of conventional photography, and holds great potential for building both new consumer cameras and scientific observation instruments. At the convergence of multiple disciplines, including computer vision, graphics, optics, and signal processing, computational photography has opened new frontiers in the past decade. Academia and industry together witnessed a series of innovative and exciting progress. The emerging field is full of opportunities and challenges. Here, we dedicate this special feature on computational photography to advancing the studies of this field.

From the viewpoint of the dimension of captured visual signals, we can categorize the studies in computational photography into several groups: spatial structure imaging, multi-spectral capture, phase imaging, temporal information recording, etc. Besides the acquisition of light signals, computational photography also benefits from the development of electrooptical technologies. To provide a comprehensive overview of this field, this special feature is composed of one invited research paper on recent progress in on-chip optical interconnects and seven invited review papers on computational photography, including an overview of the whole field and six surveys on computational acquisition along various dimensions of the visual signals.

We begin this issue with a survey on the theory, methods, and representative state of the art in this exciting field, by Prof. Qiong-hai DAI and his colleagues (Hu *et al.*, 2007). The authors give an overview of the fundamental principles and methods in computational imaging, the history of this field, and the important roles that it plays in the development of science. Then, the authors review the most recent promising computational imaging advances according to the dimensions of visual signals, and showcase the frontiers of this emerging direction. In addition, some worthwhile research topics are discussed for future development of computational imaging.

Next come the surveys on the development along the sub-dimensions of visual signals. High-resolution microscopy is a long pursuing target in both academia and industry. The development of novel computational methods would greatly benefit super-resolution microscopy and lead to better resolution, improved accuracy, and faster image processing. Prof. Peng XI and his colleagues systematically review the technologies for the broadly applicable super-resolution microscopy (Zeng *et al.*, 2017). They comprehensively describe the mainstreams of computational super-resolution microscopy, and discuss their pros and cons, from the viewpoint of bridging the microscopy and computation communities.

Along the angular dimension, light-field cameras record angular information of the physical world in addition to its spatial intensity, which provides new ways to address various tasks in computer vision, such as 3D reconstruction, saliency detection, and object recognition. Prof. Qing WANG's group and Prof. Jingyi YU extensively review the three key aspects of light field cameras, i.e., model, calibration, and reconstruction (Zhu *et al.*, 2017). They exhibit light field based applications on informatics, physics, medicine, and biology, and discuss the open issues in light-field imaging and long-term application prospects in other natural sciences.

Prof. Qiong-hai DAI
Guest Editor-in-Chief

Spectral imagers provide much more features in the spectral domain than conventional cameras, and are widely applicable in various fields such as material identification, remote sensing, precision agriculture, and surveillance. With the rapid development in computational photography theory and semiconductor techniques, spectral video acquisition becomes feasible. Prof. Xun CAO's group at Nanjing University and their collaborator Prof. David J. BRADY from Duke University contribute a review on computational spectral imaging (Chen *et al.*, 2017), which offers a review on the state-of-the-art spectral imaging technologies, especially the ones capable of capturing spectral videos. They also evaluate the performances of the existing spectral acquisition systems and discuss the developing trends.

High frame rate imaging also largely benefits from computational imaging, and we invite a review paper from Prof. Hong-wei CHEN's group (Guo *et al.*, 2017). It focuses on an unconventional architecture, single-pixel imaging (SPI), which holds potential in high-speed imaging due to extremely fast response and high sensitivity of photodiodes. Besides reviewing state-of-the-art SPI imaging techniques, the authors report a unique SPI approach based on photonic time stretch to achieve a frame rate far beyond that can be achieved by a conventional SPI. The limitations and potential applications of high-speed SPI are discussed as well.

Also, focusing on high-speed imaging, Prof. Ye-bin LIU's group introduces transient imaging, which recodes trillion-frames-per-second videos (Lin *et al.*, 2017). Such a high frame rate enables recording light traveling processes, and gives rise to new insights into the observation of visual signals. They review different transient imaging models with a time-of-flight (ToF) camera, and discuss their applications in parsing the scene information.

It is well known that the phase contains more important information about the field in comparison with the amplitude, so phase imaging is highly desired in many branches of modern science and engineering. Direct measurement of phase is difficult in the short wavelength regime of the electromagnetic spectrum, such as the visible light, due to the limited bandwidth of imaging sensors. One must employ computational techniques to extract the phase from the captured intensity. Here, we include a review from Prof. Guo-hai SITU's group. The authors introduce various iterative phase retrieval techniques and their applications in computational imaging (Situ and Wang, 2017).

In Cai *et al.* (2017), the members in Prof. Yong-jing WANG's group and the Nobel laureate Peter GRUNBERG report the experimental demonstration of on-chip optical interconnects through a monolithic integrated optoelectronic device. The experimental results pave the way towards on-chip optical interconnects using visible light. These on-chip optical interconnects provide prospects for diverse applications in computational imaging, such as intelligent displays, micro-imaging system, and flexible optical sensors.

We are pleased to include this outstanding set of papers in this special feature. We thank all the authors for their contributions. We appreciate the dedication of the reviewers for their constructive comments. We believe that these papers capture some of the latest major scientific developments in the field, and they can serve as a springboard for further improvements and developments. Great support from the editorial office is also highly appreciated.

References

Cai, W., Zhu, B.C., Gao, X.M., *et al.*, 2017. On-chip optical interconnect using visible light. *Front. Inform. Technol. Electron. Eng.*, **18**(9):1288-1294. https://doi.org/10.1631/FITEE.1601720

Chen, L.S., Yue, T., Cao, X., *et al.*, 2017. High-resolution spectral video acquisition. *Front. Inform. Technol. Electron. Eng.*, **18**(9):1250-1260. https://doi.org/10.1631/FITEE.1700098

Guo, Q., Wang, Y.X., Chen, H.W., *et al.*, 2017. Principles and applications of high-speed single-pixel imaging technology. *Front. Inform. Technol. Electron. Eng.*, **18**(9):1261-1267. https://doi.org/10.1631/FITEE.1601719

Hu, X.M., Wu, J.M., Suo, J.L., *et al.*, 2017. Emerging theories and technologies on computational imaging. *Front. Inform. Technol. Electron. Eng.*, **18**(9):1207-1221. https://doi.org/10.1631/FITEE.1700211

Lin, J.Y., Wu, R.H., Wang, H.M., *et al.*, 2017. Transient imaging with a time-of-flight camera and its applications. *Front. Inform. Technol. Electron. Eng.*, **18**(9):1268-1276. https://doi.org/10.1631/FITEE.1700556

Situ, G.H., Wang, H.C., 2017. Phase problems in optical imaging. *Front. Inform. Technol. Electron. Eng.*, **18**(9):1277-1287. https://doi.org/10.1631/FITEE.1700298

Zeng, Z.P., Xie, H., Chen, L., *et al.*, 2017. Computational methods in super-resolution microscopy. *Front. Inform. Technol. Electron. Eng.*, **18**(9):1222-1235. https://doi.org/10.1631/FITEE.1601628

Zhu, H., Wang, Q., Yu, J., 2017. Light field imaging: models, calibrations, reconstructions, and applications. *Front. Inform. Technol. Electron. Eng.*, **18**(9):1236-1249. https://doi.org/10.1631/FITEE.1601727