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Principles and applications of high-speed single-pixel imaging technology

Key words: Compressive sampling; Single-pixel imaging; Photonic time stretch; Imaging flow cytometry

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Motivation

- Single-pixel imaging technology has garnered great interest within the last decade because of its ability to record high-resolution images using a single-pixel detector. It has been applied to diverse fields, such as magnetic resonance imaging, aerospace remote sensing, terahertz photography, and hyperspectral imaging.
- Current the imaging speed of single-pixel cameras (SPCs) are limited by the response time of digital micro-mirror devices. Consequently, it is particularly challenging for SPCs to investigate fast dynamic phenomena. A non-mechanical patterned illumination generation method should be provided.

Main idea

- Inspired by the photonic time stretch technique, patterned illumination can be generated through temporal modulation (namely, spectral shaping of optical pulses) and time-to-space mapping instead of spatial modulation. Thus the generation rate of patterned illumination can be significantly improved.

- The patterned illumination generation method can be applied to single-pixel imaging and high-speed SPCs can be realized.

Method

1. Introduce the photonic time stretch technique and achieve high-speed patterned illumination generation.
2. Apply the proposed patterned illumination generation method to single-pixel imaging, high-speed SPCs are implemented.
3. The high-speed SPCs are used to observe the surface defect and the continuously flowing cells. A high-speed and high-throughput imaging flow cytometer is demonstrated experimentally.

Major results

- Our high-speed single-pixel imaging system can capture the surface morphology with data compression.

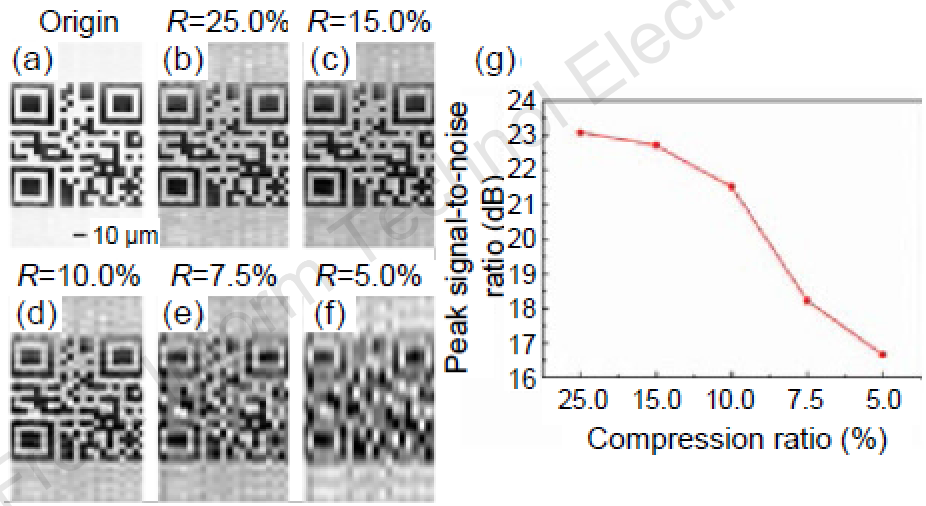

Fig. 3 Surface inspection: (a) original image of a quick response code; (b)–(f) reconstructed images at compression ratios of 25.0%, 15.0%, 10.0%, 7.5%, and 5.0%, respectively; (g) peak signal-to-noise ratio versus compression ratio curve

Major results

- Our high-speed single-pixel imaging system can capture the snapshots of flowing cells an unprecedented throughput of 30 000 cells/s.

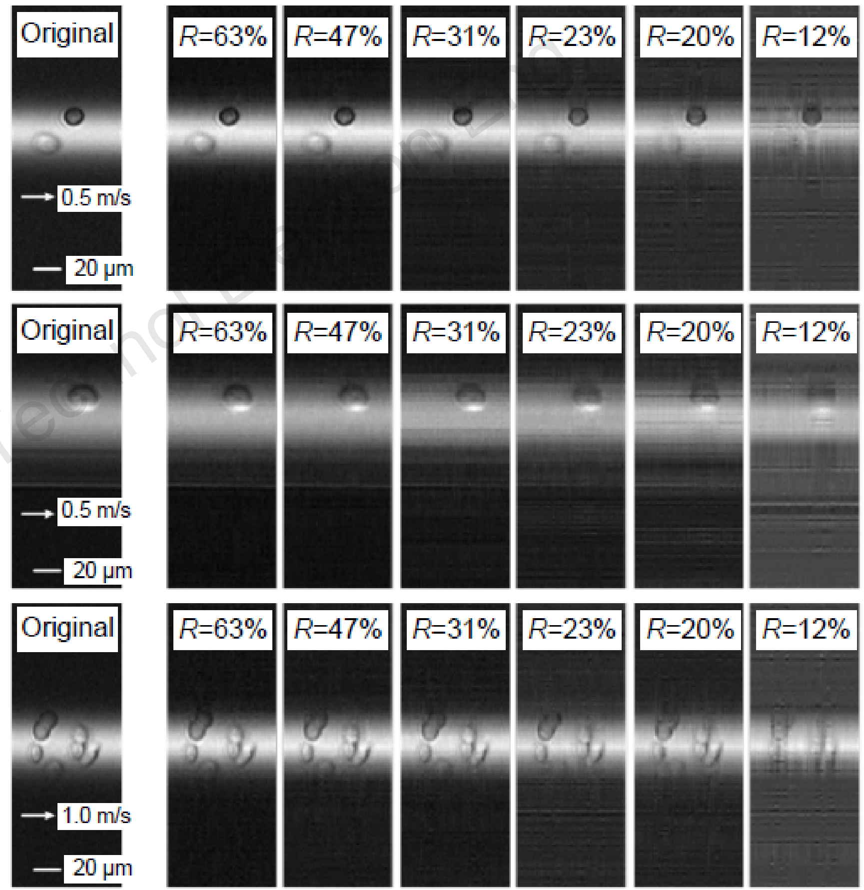

Fig. 4 Imaging flow cytometry based on time-stretch-based single-pixel imaging

Some snapshots of flowing cells reconstructed from different numbers of measurements are presented

Conclusions

- A high-speed patterned illumination generation method is proposed.
- A high-speed sing-pixel imaging system is implemented based on the patterned illumination generation method .
- An imaging flow cytometer with a high speed and an unprecedented throughput is demonstrated experimentally.
- The limitations and potential applications of the proposed high-speed single-pixel imaging system are discussed.