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Optical frequency comb profilometry using a single-pixel camera composed of digital micro-mirror devices

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In many industrial applications, the surface profile measurement of an object having a large depth is becoming very important nowadays. Our previous research has realized an optical profilometry with a wide axial dynamic range using an optical frequency comb generated by an ultra-stable mode-locked femtosecond laser and a single-pixel camera with the compressive sensing (CS) technique [1]. However, the performance was limited by the low contrast of a liquid crystal spatial light modulator. In this presentation, we demonstrate an optical frequency comb profilometry we improved the performance by using two digital micro-mirror devices (DMDs).

Figure 1 shows an experimental setup mainly composed of an optical frequency comb femtosecond laser, a single-pixel camera, and an optoelectronic interferometer. The single-pixel camera was composed of two DMDs (DMD1 and DMD2), which were aligned so that a light reflection angle caused by the characteristics was compensated, and a photodetector (PD) with an amplifier. The object wave reflected from the object was encoded by a random mask displayed on the DMDs and focused on the PD. In the optoelectronic interferometer, a specific frequency of the object and reference waves, in this experiment 0.988 GHz, was selected by a frequency selection module (FSM), respectively. The phase difference between them was measured by a phase-detection module (PDM). The phase measurement was iterated while changing the random mask. The number of the measurement points depends on the arrangement of the random mask. When the number of measurements qualified the reconstruction condition of CS, the relative depth of each point on the object surface was extracted.

Figure 2 shows a root mean square (RMS) error calculated by measuring the profile of a plane mirror using 6 × 6 random masks. The experimental results obtained from our previous system [1] are also shown. Figure 3 shows the profile of an object composed of two mirrors located at 4 cm far from each other.

[1] Q. D. Pham and Y. Hayasaki, “Optical frequency comb interference profilometry using compressive sensing,” Optics Express **21**, 19003-19011 (2013).

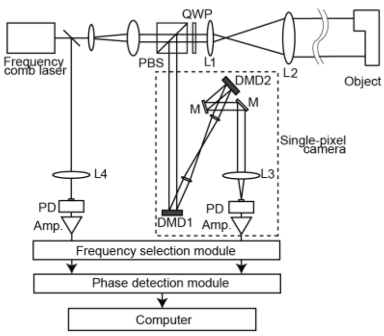

Fig. 1. Experimental setup.

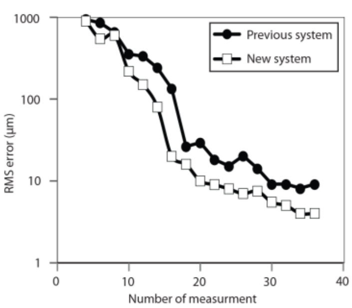

Fig. 2. Accuracy of the system.

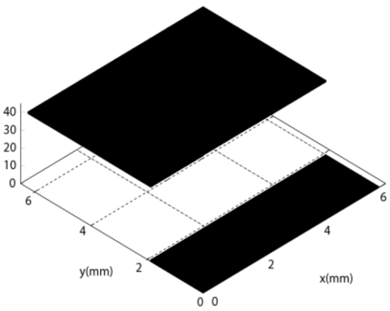

Fig. 3. Measured object's profile.