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Profilometry using optical frequency combs and compressive sensing

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Recent years, the development of optical frequency combs generated by a mode-locked femtosecond laser has been exploited to measure a distance. There have been various methods which have proposed, including a combination of time-of-flight and coherence interferometry, intermode beats of the optical frequency combs and a method in the radio-frequency domain using a sequence of higher harmonics of the repetition rate.

In this presentation, we demonstrate a new optical profilemetry based on the compressive sensing (CS) technique and an optical comb frequency generated by a mode-locked femtosecond laser. The femtosecond laser and electronic components as shown in Fig. 1 are used to measure the relative phase information of the all object points and the CS allows reconstructing the entire the object surface from relatively few measurements.

In the experimental setup as described in Fig. 1, the incident optical wave from the object surface was led to spatial light modulation, which was displayed the pseudorandom pattern generated by the random number generators. The coded optical wave contained the amplitude and phase information of all object points was summed up and focused on the sensor of a fast photo-receiver D1 by lens L1. The wave reflected from the M1 or M2 was used as reference. A specific frequency of the object and reference waves, which qualified the condition of the selectable frequency system, was selected by frequency selectable system. The phase difference between the coded object wave and reference wave was measured by a phase-detector. The process was repeated until the number of measurements qualified the reconstruction condition of CS, the relative depth information of the each point on the object surface was extracted. M1 and M2 were organized as a phase-shifting component so that the dependence of the phase measurement of the phase-detector on the change in the intensity of the light reflected from the object is eliminated; the phase difference is specified, exactly.

The experiment results, which were performed with a mirror to examine the accuracy of the system and with an object constructed by two mirrors located at 4 cm far from each other, were shown in Fig. 2 and 3, respectively.

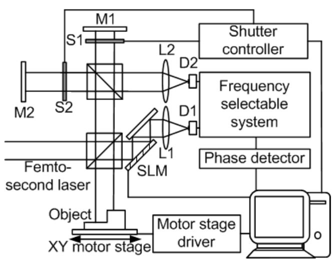

Fig. 1. Experiment setup

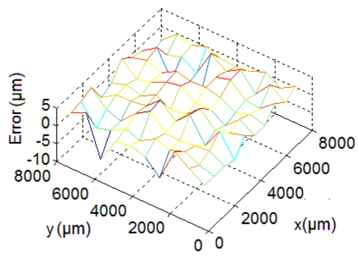

Fig. 2. The accuracy of the system

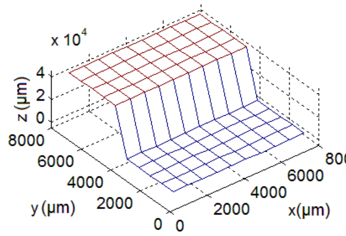

Fig. 3. Measured object profile