AMCW 3D Laser Scanner Employing Optical Attenuator for Avoidance of Receiver Saturation

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With the development of Industry 4.0 [1] in recent years, amplitude-modulated continuous wave (AMCW) 3D laser scanner proves to be a powerful instrument for 3D measurement in "smart factories" [2] for assessment of automatically manufactured components, due to its advantages such as high spatial resolution, illumination independence etc. However, owing to the saturation of receiver electronics, such laser scanners suffer from severe data loss in point clouds for measuring objects with high reflectivity. This presents formidable challenges when transforming 3D point clouds to solid 3D model for shape inspection and reverse engineering etc. In this paper, we investigate this problem in detail, and recover data loss by employing a variable optical attenuator (VOA) in the receiver.

AMCW 3D laser scanner generates continuous light with periodically modulated intensity. The distance is determined by the phase difference (D) between transmitted light and reflected light [3,4] (Fig. 1). In this experiment, sinusoidally-modulated light at 1.53 um is employed for scanning the object under measurement. When received optical power exceeds the threshold of receiver optoelectronics, the detected waveform distorts, resulting in failure of determining the phase difference, and thereby causing data loss in point clouds. To examine this problem, we modified the receiver configuration by inserting a variable optical attenuator (VOA) after the Erbium-doped fiber amplifier (EDFA) (Fig. 2) and did several measurements of the same sample with different attenuation.

An air duster can (Fig. 3a) was selected as the sample to be measured. The sample was fixed on a stage to make sure the incident angle of the laser scanner was same for each measurement. The first measurement was carried out without attenuation for reference, where we can see data loss was obvious as indicated in the red circle in Fig. 3b. As the attenuation was gradually increased until 12 dB, lost data points in Fig. 3b were successfully obtained (Fig. 3c). Fig. 3d shows the result of aligning the 3D point clouds of measurements with 0 dB and 12 dB attenuation, where the point clouds with 12 dB attenuation perfectly filled the voids in point clouds without attenuation.

Automatic product assessment in smart factories can be realized with 3D laser scanner due to its advantages such as high resolution and high accuracy. However, data loss caused by receiver saturation is a serious issue which poses difficulties in merging point clouds to a smooth surface. We explored the receiver saturation with VOA and recovered data loss with attenuation at 12 dB.

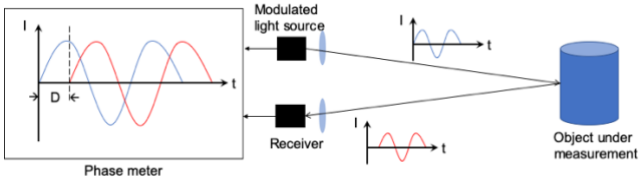

Figure 1 Principle of AMCW 3D laser scanner

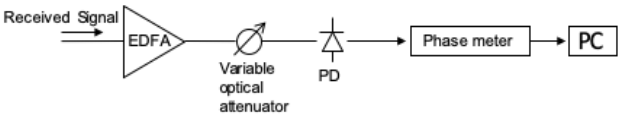

Figure 2 Modified configuration of the receiver of AMCW 3D laser scanner with VOA

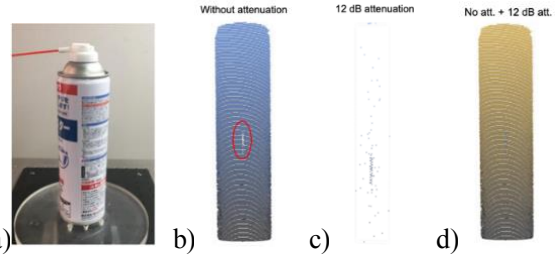

Figure 3 a) Sample under measurement; b) 3D point clouds without attenuation, c) with 12 dB attenuation, d) result of combining b) and c)

Reference:
[1] H. Lasi *et al.*, Business & Information Systems Engineering, vol. 6, pp. 239–242, 2014.
[2] J. Lee, *Informatik-Spektrum*, vol. 38, pp. 230-235, 2015.
[3] M. D. Adams *et al.*, *The International Journal of Robotics Research*, vol. 15, pp. 441–458, 1996.
[4] C. Zhang *et al.*, *CLEO*, JTh2A.85, May 2019.