한국소음진동공학회 2013년 추계학술대회논문집, pp. 763~764

광공진 현상을 이용한 입체 영상센서 및 신호처리 기법

Optical Resonance-based Three Dimensional Sensing Device and its Signal Processing

박용화† · 유장우 · 박창영 · 윤희선*

Yong-Hwa Park, Jang-Woo You, Chang-Young Park, Heesun Yoon

Key Words : 3D imaging(입체영상), 3D camera(입체카메라), Optical resonance(광공진), Time of flight (왕복비행시간법)

Abstract

A three-dimensional image capturing device and its signal processing algorithm and apparatus are presented. Three dimensional information is one of emerging differentiators that provides consumers with more realistic and immersive experiences in user interface, game, 3D-virtual reality, and 3D display. It has the depth information of a scene together with conventional color image so that full-information of real life that human eyes experience can be captured, recorded and reproduced.

20 Mega-Hertz-switching high speed image shutter device for 3D image capturing and its application to system prototype are presented[1,2]. For 3D image capturing, the system utilizes Time-of-Flight (TOF) principle by means of 20MHz high-speed micro-optical image modulator, so called 'optical resonator'. The high speed image modulation is obtained using the electro-optic operation of the multi-layer stacked structure having diffractive mirrors and optical resonance cavity which maximizes the magnitude of optical modulation[3,4]. The optical resonator is specially designed and fabricated realizing low resistance-capacitance cell structures having small RC-time constant. The optical shutter is positioned in front of a standard high resolution CMOS image sensor and modulates the IR image reflected from the object to capture a depth image (Figure 1). Suggested novel optical resonator enables capturing of a full HD depth image with depth accuracy of mm-scale, which is the largest depth image resolution among the-state-of-the-arts, which have been limited up to VGA. The 3D camera prototype realizes color/depth concurrent sensing optical architecture to capture 14Mp color and full HD depth images, simultaneously (Figure 2,3). The resulting high definition color/depth image and its capturing device have crucial impact on 3D business eco-system in IT industry especially as 3D image sensing means in the fields of 3D camera, gesture recognition, user interface, and 3D display. This paper presents MEMS-based optical resonator design, fabrication, 3D camera system prototype and signal processing algorithms.

Reference:

[1] Y. H. Park et al., "Micro optical system based 3-D imaging for full HD depth image capturing,"Proc. SPIE 8252, 82520X (2012).

[2] Y. H. Park, J.W. You, and Y. C. Cho, "Three-dimensional image acquisition apparatus and method of extracting depth information in the 3-D image acquisition apparatus," KP2010-0133720, U.S. Patent 13/160,135 (2011).

[3] Y. C. Cho et al., "Optical modulator," KP2010-0006052, U.S.- 2011- 0181936-A1 (2011).

[4] Y. C. Cho et al., "Optical modulator using multiple Fabry–Perot resonant modes and apparatus for capturing 3-D image including the optical modulator," KP2010-0137229, U.S. Patent 13/163,202 (2010).

† 교신저자; 정회원, 삼성전자 종합기술원, yongh.park@samsung.com, Tel : 031-280-9459 Fax: 031-280-9158

* 공동저자: 소속 상동

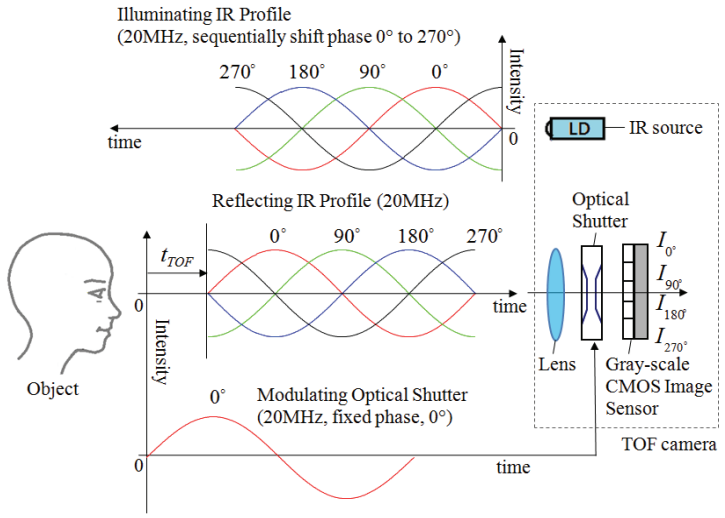

Figure 1. Schematic optical signal processing with Time of Flight (TOF) operation. IR source illuminates object with sinusoidal intensity modulation. Phase shifts of (0°, 90°, 180°, 270°) are applied in IR modulation sequentially, and optical shutter is modulated with fixed phase shift (0°). Modulated IR images through the optical shutter are sequentially captured by CIS resulting in 4 images ($I_{0°}$, $I_{90°}$, $I_{180°}$, $I_{270°}$). Depth image is extracted by using these 4 images

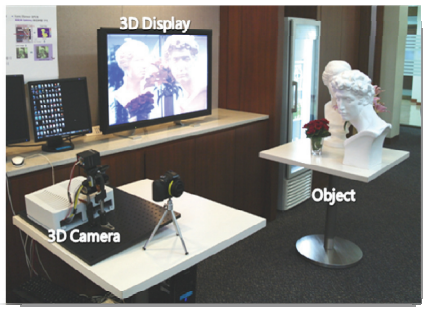

Figure 2. 3D image capturing test setup: color and depth images of objects are captured by suggesting 3D camera prototype with optical shutter and the color/depth images are converted to multi-view format of 3D display.

Figure 3. Captured 14Mp color (left) and full HD and depth (right) images