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A Study on Depth Information Acquisition Improved by Gradual Pixel Bundling Method at TOF Image Sensor

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Abstract

The depth information of an image is used in a variety of applications including 2D/3D conversion, multi-view extraction, modeling, depth keying, etc. There are various methods to acquire depth information, such as the method to use a stereo camera, the method to use the depth camera of flight time (TOF) method, the method to use 3D modeling software, the method to use 3D scanner and the method to use a structured light just like Microsoft's Kinect. In particular, the depth camera of TOF method measures the distance using infrared light, whereas TOF sensor depends on the sensitivity of optical light of an image sensor (CCD/CMOS). Thus, it is mandatory for the existing image sensors to get an infrared light image by bundling several pixels; these requirements generate a phenomenon to reduce the resolution of an image. This thesis proposed a measure to acquire a high-resolution image through gradual area movement while acquiring a low-resolution image through pixel bundling method. From this measure, one can obtain an effect of acquiring image information in which illumination intensity (lux) and resolution were improved without increasing the performance of an image sensor since the image resolution is not improved as resolving a low-illumination intensity (lux) in accordance with the gradual pixel bundling algorithm.

Keywords: *Depth Information, Depth Camera, TOF Camera*

1. Introduction

The depth information of an image is used in a variety of applications including interaction, game device, motion recognition, 3D modeling, keying, 2D/3D conversion, multi-view extraction, etc. There are various methods to acquire depth information, such as the method to use a stereo camera, the method to use the depth camera of flight time (TOF) method, the method to use 3D modeling software, the method to use 3D scanner and the method to use a structured light just like Microsoft's Kinect. In general, it is required to use expensive equipment in order to obtain the depth information of a high resolution or have a process of modifying and complementing through an additional image processing process of depth information. Thus, it

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is necessary to propose a measure to acquire efficient and accurate depth information[1].

In particular, one should depend on the sensitivity of optical signal of an image sensor (CCD/CMoS) to obtain infrared light image information from the depth camera of TOF method[2]. Infrared light area requires broader sensor area due to low energy as compared with visible ray or ultraviolet ray. As a result, the existing TOF depth camera method gets an infrared light image by bundling several pixels; thus, this reduced the resolution of an inputted image. Therefore, this thesis proposed a measure to acquire a high-resolution image through gradual area movement while acquiring a low-resolution image through pixel bundling method.

2. Depth Camera of TOF (time of flight) Method

The method of acquiring depth information is classified into the passive method and the active method as shown in Figure 1. The passive method is to acquire depth information from two-dimensional image acquired by stereo and multi-view shooting. The active method is to measure depth information directly with depth camera or laser scanner for TOF method[3].

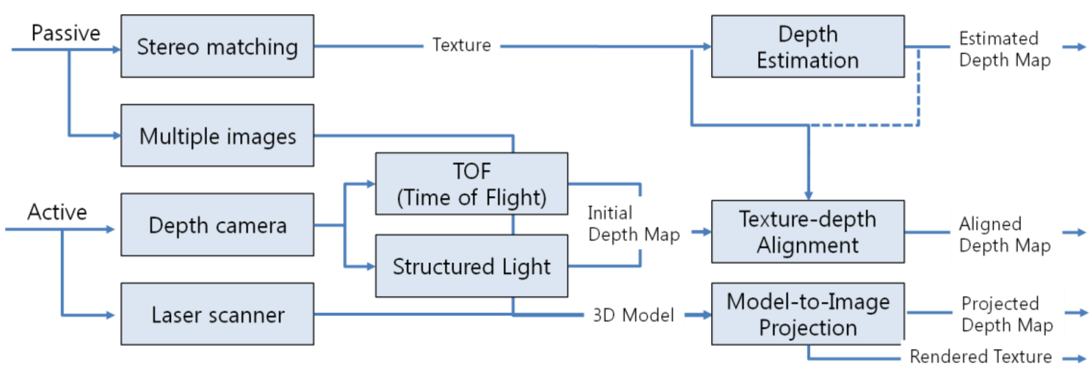
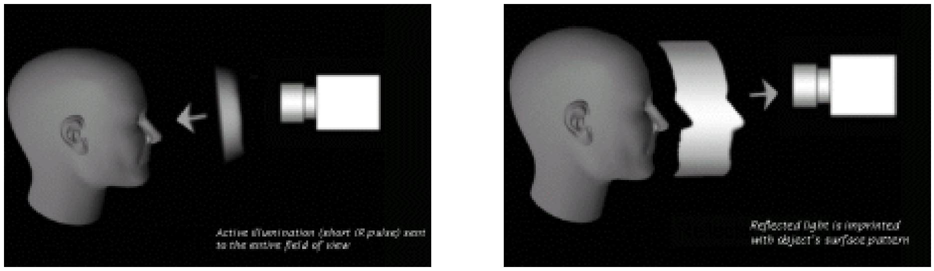


Figure 1. Acquisition method of depth Information

The depth camera of TOF method among the active method is created by TOF principle. The basic principle is to find a depth value by calculating the phase shift of light, in other words, the time to be returned after the light is reflected by irradiating the light[3][4]. Therefore, the measured distance is proportional with the time of light that progresses from the camera to an object. The figurative concept for measuring the depth information is as shown in Figure 2. Wherein, the light wall is contacted with 3D object of an image as shown in Figure 2(a) and the waveform of an object shape reflected from the object surface is represented in the form of Figure 2(b). The reflected waveform includes all the information required for the recovery of object shape. In other words, the image shape of reflected light wall may be recovered to the shape of an actual object. The depth information from the camera is acquired as a grey image of each pixel having an intensity that is proportional with the distance[3][5].



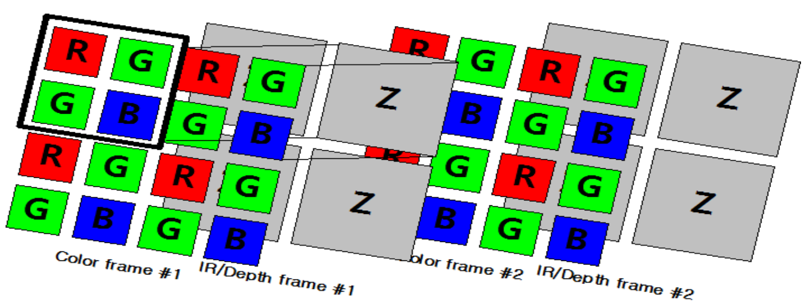
(a) (b)

Figure 2. 3D scene for emitting and reflecting (a) Light wall moving towards 3D scene (b) Light wall reflected from 3D scene

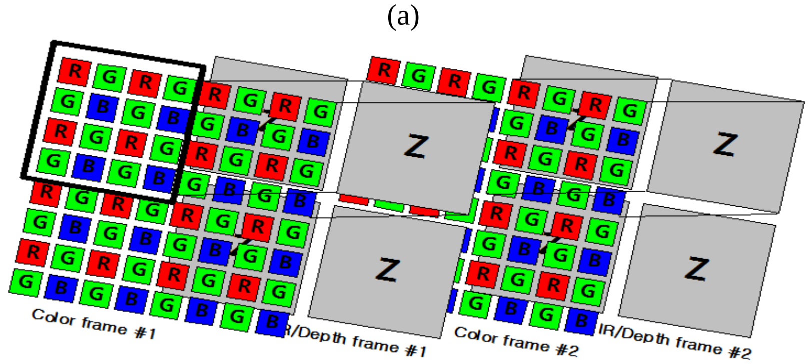
3. Proposed Gradual Pixel Bundling Method

3.1 Pixel Bundling Method

In general, it is required to get an image reflected from an object after illuminating with infrared light LED in order to acquire an image of low-illumination intensity at an image sensor (CCD/CMOS). If the illumination intensity is insufficient, 4 sub pixels are processed as a single bundling as shown in Figure 3(a)[6]. The improved image sensor is consisted of 4 bundling of 1 pixel that consists of 4 sub pixels as shown in Figure 3(b); as a result, it becomes possible to accept an image at a very low illumination intensity. The pixel bundling method to acquire an image of low illumination intensity has the disadvantage that the resolution of depth information would be degraded.



(a)



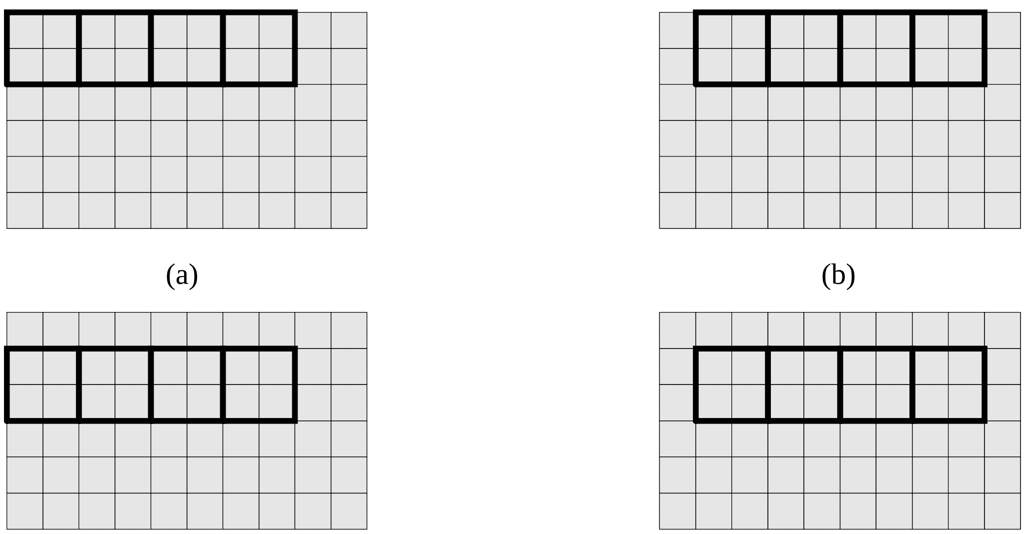
(b)

Figure 3. Pixel bundling method (a) Sub pixel bundling method structure (b) Bundling of 4 pixels, each of which is consisted of 4 sub pixels

3.2 Gradual Pixel Bundling Method

Gradual pixel bundling method acquires image information by bundling 4 pixels as a single shape and moving them gradually to X-axis and Y-axis as shown in Figure 4. Even an image with low illumination intensity can be acquired and it is also possible to maintain the resolution of the original sensor at the same time. Its important feature is that it has the structure to resolve the low illumination intensity issue at the existing image sensor by using pixel bundling method in Figure 4(a). Figure 4(b), (c) and (d) represents the structure to resolve the downgraded image resolution of pixel bundling method.

Gradual pixel bundling method first bundles several pixels (2x2 or 4x4) of square area into a single unit in order to increase the illumination intensity of an image. This improves the illumination intensity since it received more image signals as the input unit area is broadened by 4 or 16 times. Second, it provides a device and method to acquire image information of a low illumination intensity (lux) of a high resolution by selecting pixel bundling method and gradual movement method as a way to avoid resolution degradation of an image.



(a) (b) (c) (d)

Figure 4. Gradual pixel bundling method (a) Pixel bundling (b) X-axis sub pixel movement (c) Y-axis sub pixel movement (d) X and Y-axis pixel movement

4. Conclusion

The depth information of an image is applied to a variety of fields; thus, it is required to acquire efficient and accurate in-depth information. In general, the depth camera of TOF method allows for acquiring accurate in-depth information in real-time as compared with the other acquisition methods for depth information. However, pixel bundling method acquires a low resolution in order to acquire an image with a low-illumination intensity.

This thesis proposed an algorithm to convert pixel bundling into an adaptive one for real-time processing at TOF sensor. The resolution is not improved even though the issue of a low-illumination intensity (lux) is resolved in accordance with the adaptive pixel bundling algorithm that is applied to the image signal processing area. Therefore, it is possible to acquire image information having an improved illumination intensity and resolution even without improving the performance of an image sensor. It is expected that the proposed technique will be used in infrared light CCTV (Closed Circuit Television) system and the depth camera of TOF (Time of Flight) method.

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