Enhancing Edge Detection of Depth Image by Bilateral Filter and Morphological Operations

Thai Leang Sung and Hyo Jong Lee

June 27, 2019

Enhancing Edge Detection of Depth Image by Bilateral Filter and Morphological Operations

Thai Leang Sung
Department of Computer Science and Engineering
Chonbuk National University
567 Baekje-daero, Deokjin-gu, Jeonju-si, Jeollabuk-do, South Korea
thaileang@jbnu.ac.kr

Hyo Jong Lee
Department of Computer Science and Engineering, CAIIT
Chonbuk National University
567 Baekje-daero, Deokjin-gu, Jeonju-si, Jeollabuk-do, South Korea
hlee@chonbuk.ac.kr

***Abstract*—Edge detection in depth image remains a challenge in computer vision. In this paper, we propose an enhancement of depth edge detection using bilateral filtering and morphological operations such as erosion and dilation. The edge detection is done based on Canny Edge detection principle. The results have shown that this method provided better results than the method without the enhancement.**

***Keywords*—kinect, depth image, edge detection**

I. INTRODUCTION

Edge detection in RGB image has been successfully researched, but it is still a challenge for depth edge detection in computer vision field.

Accurate edge detection from a depth image is essential for some object detection processes [1], which are dependent on a model of a particular shape. A proper edge detection process can be used for various Human action analysis problems in a real environment such as walking, spotting and sitting [2]. However, existing edge detection process in depth images cannot be applied in these types of situations due to some limitations. Some methods of edge detection in depth image failed to deliver noise-free depth images; thus, proper edge detection cannot be achieved.

In this paper, we proposed a method that can detect edges from depth images much better. We use Canny edge detection [3] to detect continuous edges along with the incorporation of morphological operation [4]. This operation generally consists of two operators; erosion and dilation. The first operation denoted as opening, smooths the contour object, break narrow strips and eliminates thin protrusions. The second operation, called closing, also smooths contours but in contrast with opening; it fuses thin discontinuities, eradicate trivial holes and fills gaps in the contour.

In section 2, we will explain about our depth detection algorithms i.e. smoothing algorithm, morphological operation, and canny edge detection and its modification. Section 3 is our experimental results for different scenes and compare the results with the method that doesn't have the enhancement. Finally, Section 6 concludes this research paper.

II. PROPOSED APPROACH

In Figure 1, we have illustrated the process of the proposed system. We have input depth image[1] input to the detection process. Then we obtain an output edge image as a result. In the detection processing, the depth image will go through smoothing algorithm before the process of edge detection and morphological operation are applied.

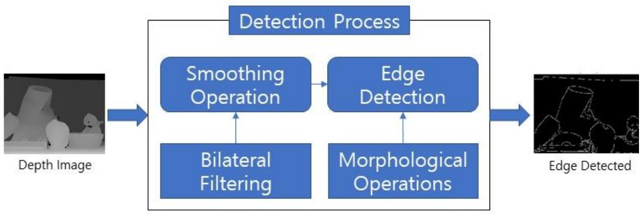
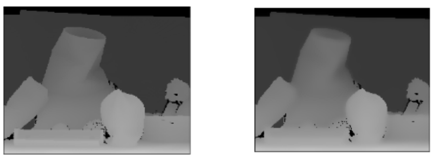


Figure 1 Proposed Approach

In the following we will describe the depth edge detection process step by step respectively.

A. *Smoothing Algorithm*

Smoothing algorithm is used to reduce the level of noises in depth image. Here, we use Bilateral Filtering [5].



(a) (b)

Figure 2. (a) Original Depth Image, (b) Filtered Image

[1] *Middlebury and NYUDepthV2*

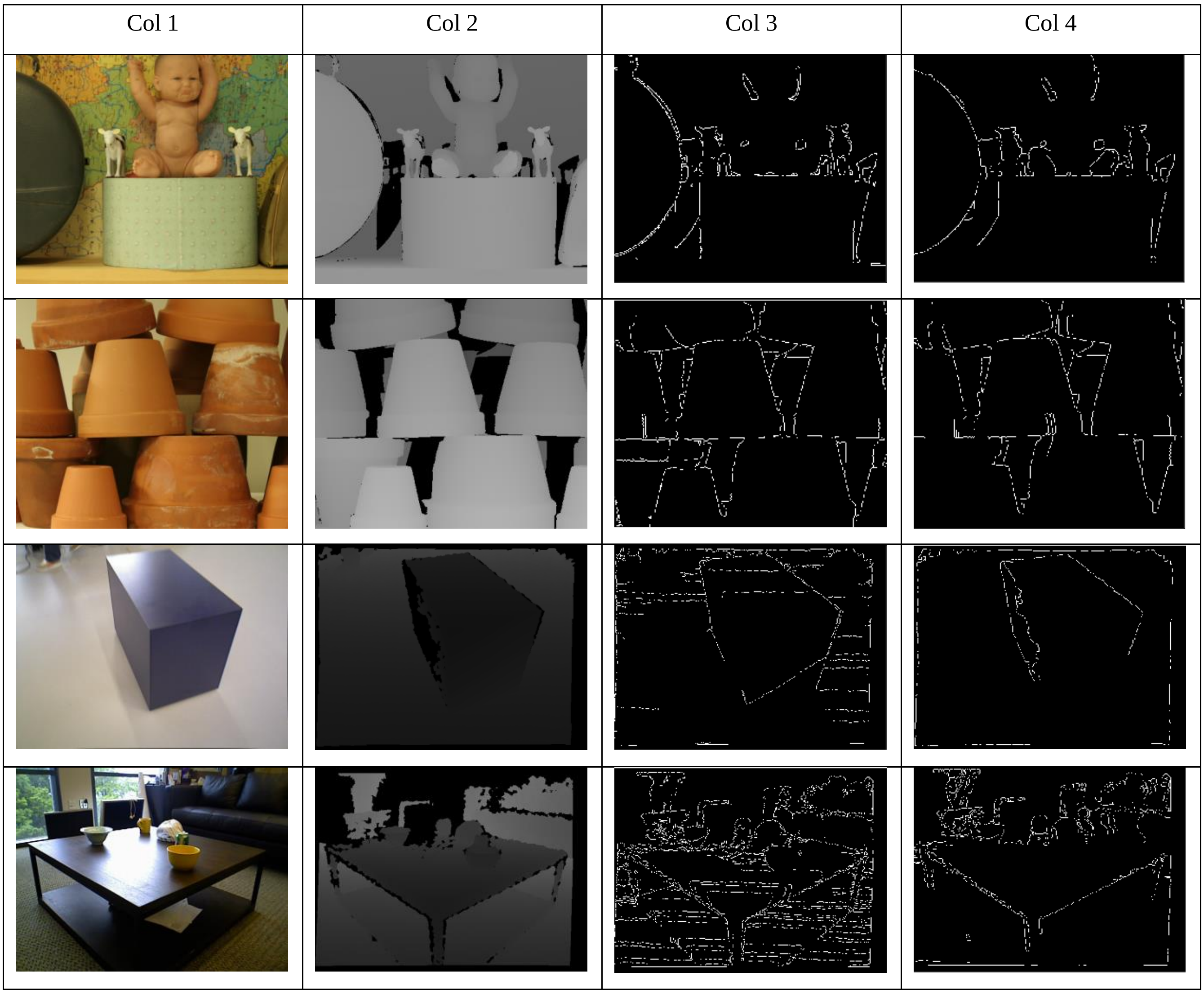


Figure 3. Edge detection result in depth image for vaious scenes

We chose bilateral filter, because it is non-linear technique that can blur an image while respecting strong edges. Its ability to decompose an image into different scales without causing

haloes after modification has made it ubiquitous in computational photography application such as tone mapping, style transfer, relighting, and denoising which partial demanded in our study.

B. Edge detection algortihm in depth image

Our base edge detection algorithm is Canny edge detection [6, 7], but we modified it with Morphological operation, as we mention above.

1) Canny edge detection

Canny edge detection algorithm can be categorized into five different steps:

- Smoothing: To remove noise from the image, smoothing or blurring operation are performed.
- Finding gradients: After having the gradients of the image, edges should be marked only in those areas where large magnitudes are obtained.
- Non-maximum suppression: Only local maxima should be considered as edges.
- Double thresholding: Prospective edges are determined by double thresholding.
- Edge tracking by hysteresis: After suppressing all the edges that are not connected to a very certain or strong edges, those will be considered as the final edges.

We already used smoothing filter at the first stage. We skipped the first step and the other steps had been done for our method.

2) Morphological operations

We have modified the edge detection process using morphological operations [8]. We have used a morphological operation that is represented as a combination of erosion and dilation. The first operation is called *opening* and the other is called *closing*.

Opening is a morphological filter where erosion is followed by dilation; and closing is a morphological filter where dilation is followed by erosion. The reason for calling this operation opening is because it can open up a gap between objects connected by a thin bridge of pixels. Closing is originated because it is able to fill holes in the regions while keeping the initial region sizes unchanged.

These morphological operations can be explained in term of set-theoretic operations such as the complement of binary image:

$f^c(a,b) = 1\ iff(a,b) = 0,$

$and\ f^c(a,b)\ =\ 0\ if\ f(a,b)\ =\ 1$

Here, the complement, f^c is the set of elements that are not contained in image f.

Now, the intersection $I\ =\ f\ \cap\ g$ of two binary images f and g can be explained as the following equations:

$I(a,b)\ =\ 1\ if\ f(a,b) =\ 1$

$g(a,b)\ =\ 1, and\ I(a,b) =\ 0\ otherwise$

The *union* $U\ =\ f\ \ U\ g$ of two binary images f and g can be explained as the following equations:

$U(a,b) = 1iff(a,b) = 1$

$or\ g(a,b) = 1,$

$and\ U(a,b)\ =\ 0\ otherwise$

III. Result and comparison

Figure 2 illustrated the different between the original depth image (a) and the smooth image after applying smooth operation (b). We have our result in Figure 3 as follows: Col 1 represent RGB image and Col 2 denotes the raw depth image of the particular objects and scenes. Col 3 is the result of edge detection using existing method. And, the last column is the results of our approach. In the Col 3, some of the edges information were not preserved, which were preserved by our method. The last two results have proved that our technique is better detected.

IV. Conclusion

In this study, we propose a method that improve the depth image edge detection using image-based smoothing – bilateral filter, and modification of the Canny edge detection by incorporate with morphological operations. According to the results, the well-built depth images do not appear to be different in the edge detection process, but our method performs better in the noisy depth images.

Acknowledgment

This research is supported by the MSIP (Ministry of Science, ICT and Future Planning), Korea, under the ITRC (Information Technology Research Center) support program (IITP-2018-2015-0-00378) supervised by the IITP (Institute for Information & communications Technology Promotion). This research was also supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (GR 2016R1D1A3B03931911). This work was also supported by the Technological Innovation R&D Program (C0531466) funded by the Small and Medium Business Administration (SMBA, Korea).

References

[1] Xia, Lu, Chia-Chih Chen, Aggarwal Jake K., "Human detection using depth information by kinect", 2011 IEEE Computer Society Conference on Computer Vision and Pattern Recognition Workshops (CVPRW),IEEE.

[2] Eum Hyukmin, Yoon Changyong, Lee Heejin, Park Mignon, "Continuous human action recognition using depth-MHI-HOG and a spotter model", Sensors 2015;15(3)5197–227.

[3] J. Canny, "A Computational Approach to Edge Detection", IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol. 8, No. 6, Nov. 1986.

[4] Megha Goyal, "Morphological Image Processing", IJCST Vol. 2, Issue 4, Oct. - Dec. 2011

[5] Sylvain Paris, Pierre Kornprobst, Jack Tumblin, and Fredo Durand, "Bilateral Filtering: Theory and Application", Foundation and Trends in Computer Graphics and Vision, Vol. 4, No. 1 (2008) 1-73

[6] John Canny, "A Computational Approach to Edge Detection", IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol. PAMI-8, No. 6, Nov. 1986

[7] Moeslund T. Canny Edge detection. Denmark: Laboratory of Computer Vision and Media Technology, Aalborg University. March 2009.

[8] Pierre Soille, "Morphological image analysis", Principles and applications, ISBN 3-540-65671-5 (1999), 2nd edition (2003)