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Depth edge detection by image-based smoothing and morphological operations

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Abstract

Since 3D measurement technologies have been widely used in manufacturing industries edge detection in a depth image plays an important role in computer vision applications. In this paper, we have proposed an edge detection process in a depth image based on the image based smoothing and morphological operations. In this method we have used the principle of Median filtering, which has a renowned feature for edge preservation properties. The edge detection was done based on Canny Edge detection principle and was improvised with morphological operations, which are represented as combinations of erosion and dilation. Later, we compared our results with some existing methods and exhibited that this method produced better results. However, this method works in multiframe applications with effective framerates. Thus this technique will aid to detect edges robustly from depth images and contribute to promote applications in depth images such as object detection, object segmentation, etc.

Keywords: Edge; Depth Image; Smoothing; Morphology

1. Introduction

As depth edges represent object contours [1,2], proper edge detection offers a significant role in various computer vision problems. Edge maps contain part of geometric information of natural scenes; especially in the case of depth images, depth discontinuities separate foreground objects from the background and can be used for various image processing tasks such as segmentation or denoising [3]. Even though there have been some rapid progresses in the field of image patch classification [4–6] object detection is still an active research topic.

The 3D measurement technology is generally based on calculating depth information of objects in a scene. There has been some work in 3D measurement technologies, where researchers tried to acquire the depth information of objects in a scene by using stereo cameras [7–9]. However, this approach is limited because stereo cameras are able to work in the scenes containing plentiful textures. Some people used three dimensional laser range finders [10,11]. They were successful to produce accurate depth data. But they cannot use this device to real-time applications due to their expensive apparatus. Even some pattern-based methods [12–15] were used to produce a depth map but those methods also have some limitations with respect to the cameras and object positions. Since the rapid growth of the availability of inexpensive RGB-D sensors such as Apple Prime Sense, Microsoft Kinect, Intel Real Sense, etc., a lot of break-throughs have been achieved for several tasks such as 3D modeling [16], segmentation [17] and body pose estimation [18,19]. Though these sensors helped us to achieve depth maps but very few methods have been applied to analyze such maps in terms of edge detection.

Accurate edge detection from a depth image is essential for some object detection processes [20], which are dependent on a model of particular shape. A proper edge detection process can be used for various Human action analysis [21] problems in a real environment such as walking, spotting and sitting. Existing edge detection processes in depth images, however, cannot be applied in these types of situations due to some limitations. Some methods of edge detection in depth images [22] failed to deliver noise-free depth images; thus proper edge detection cannot be achieved.

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Some other methods [22,23] work in edge detection in depth images. However, they only work for a single frame. When they are applied to problems requiring processing multi-frames, these methods may fail as they cannot deal with newly generated noises in each frame, such as flickering problems.

In this paper, we proposed a method that can detect edges from depth images more profoundly. This method can detect continuous edges, which are very important when we try to detect a large object from an image such as a human body. To detect continuous edges, we modified the Canny edge detection method by incorporating morphological operation. The morphological operation generally deals with shape of features in an image. It has been used to remove imperfections from various types of shape such as object boundaries, skeletons, etc. This operation generally consists of two operators; erosion and dilation. The first operation, denoted as opening, smooths the contour object, breaks 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. This method also works in multi-frames, whereas the previous methods detect edges in a single frame.

This paper is structured as follows: Section 2 explains the overall framework of the proposed system. It also presents the way by which a depth image is acquired. In Section 3, we present a process for smoothing the depth image. Section 4 represents an edge detection process in the depth image. In Section 5 we show our experimental results for different scenes and compare our results with an existing method. Finally Section 6 concludes this paper along with some directions for possible future work.

2. Overall framework

In Fig. 1 we have illustrated the overall framework of the proposed system. Here, a depth image has been acquired by using Microsoft Kinect. The data captured from Kinect has to be processed in a certain way. After proper processing of the Kinect data we smooth the depth image for reducing the level of noises using the principle of Median filtering. Later, we move on to the edge detection process with the smoothed depth image. Here, we use the principle of Canny Edge Detection and modified it with Morphological operations for gaining better performance. The morphological operations are opening and closing operations. In this section we discuss the technical approaches for gaining the depth image from Kinect and process it for additional applications. Microsoft provides some built-in libraries which have been used in this work for acquiring the depth image. However, there are some preprocessing task for using Microsoft Kinect. **NuiGetSensorCount function** has been used to make sure the numbers of sensors ready for use. **NuiImageResolutionToSize** function has been used to make sure the numbers of sensors ready for use. **NuiImageResolutionToSize** function has been used to acquire the width and height of the depth frame and **INuiSensor:: NuiImageStreamOpen** function has used to initialize the sensor to stream out the depth data. Once we have started to get the depth stream we had started to capture the data from the next frames by using INuiSensor:NuiImageStreamGetNextFrame and by using INuiSensor:NuiImageStreamReleaseFrame each frame has been released after saving it.

Once we capture the depth data frame by frame it is essential to converse with Kinect to get the depth data, particularly one frame at a time. In this situation, we have used an abstract base class called KinectHelper which holds the functions for this type of communication. Here, we have used KinectHelper: UpdateDepthFrame method to update the frame of depth data and later by using KinectHelper:GetDepthImageAsArgb we acquired the Kinect data formatted as ARGB. Once we found this data we would be able to progress our later algorithms as per our later obligations.

3. Depth image smoothing algorithm

In this section we will explain the principle that we have used to reduce the level of noises in our acquired depth image. Here we have used the Median filtering principle [24].

There are several filters for removing noises from images. However, the median filter is different from most of the existing ones. The most important feature of Median filter is that it preserves edges while removing noises. Basically, Median filter analyzes through every image pixel and replaces

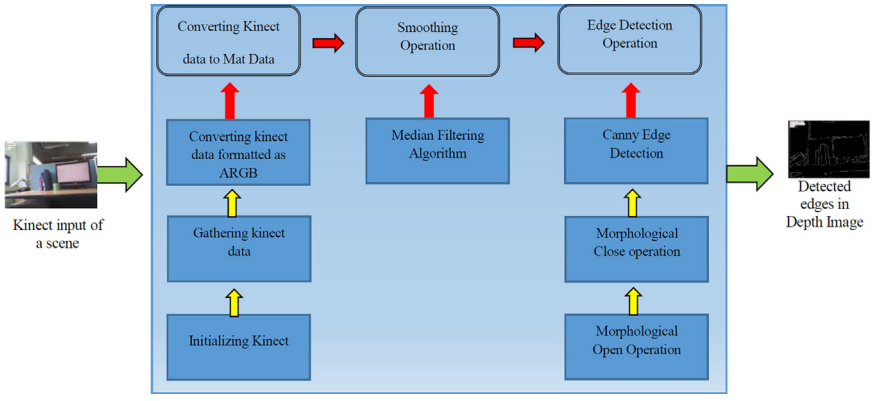

Fig. 1. Overall framework.