3D Modeling and WebVR Implementation using Azure Kinect, Open3D, and Three.js

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Abstract—This paper proposes a method of extracting an RGB-D image using Azure Kinect, a depth camera, creating a fragment, i.e., 6D images (RGBXYZ), using Open3D, creating it as a point cloud object, and implementing webVR using three.js. Furthermore, it presents limitations and potentials for development.

I. INTRODUCTION

Recently, the mobile device with LiDAR sensor, e.g., Ipad Pro4, has been released and Apple has announced that it will release Apple Glass. After the VR industry emerged, it has been receiving a lot of attention from the academia and the public about virtual environments such as VR, AR, and MR around the world [1], [2].

Bringing the real world into virtual reality is another area of VR. The way to implement it is to use a sensor (e.g., Microsoft’s Azure Kinect, Intel’s RealSense, etc.) to get an RGB-D image. The information obtained from the sensor is made into a mesh or point cloud through registration process which convert RGB-D image to point cloud (RGBXYZ) and data pre-processing using the platform (e.g., Unity, Unreal Engine, or Open3D). After that, rendering is done through a data rendering platform (e.g., Hologram, Light Field, or VR).

This paper supposes a method that restores the data received from the vision sensor into a complete point cloud and render it, using Azure Kinect as a vision sensor, preprocessing data using Open3D, and rendering it in WebVR.

II. SENSING AND DATA-PROCESSING

A video of a total of 240 frames was obtained by photographing a room, and this was extracted as a color image and a depth image pair. Azure Kinect, an RGB-D sensor, was used for shooting, and data was obtained using Azure Kinect SDK. Fig. [1] is a comprehensive representation of data processing. From the extracted 240 color images, depth images, and pinhole camera intrinsic matrix, 240 point clouds are created and mapped to 240 nodes. Divide all the consecutive nodes by \( N \) and group them. The nodes can be expressed as follows:

\[
\mathcal{A} = \{a_1, a_2, \ldots, a_M\}
\]

And for the above node set, suppose that source and target nodes exist. \( a_s \) and \( a_t \) represent a source node and a target node, respectively. \( s \) and \( t \) represent the indexes of the source node and the target node, respectively, which are following

\[
1 \leq s < t < s + N \leq M.\]
performed for each data in order to reduce the amount of computation to obtain the pose graph. Then, proceed with pose graph optimization using Jacobian RGB-D odometry method [10]. When the optimal pose graph is obtained, a linear transformation operation is taken for each node and edge, and the position and phase are matched for $N$ consecutive point clouds. As a result, $K$ point clouds can be obtained where $K = \lceil 240/N \rceil$. The set of point clouds is denoted as $\mathcal{P} = \{p_1, \ldots, p_k, \ldots, p_K\}$. And it can be shown in Fig. 2.

This process is called ICP-Registration.

After that, ICP-registration is performed for the $K$ point clouds $\mathcal{P}$ that have been locally registered in the similar way as above to match the location and image of the entire frame. For all natural numbers $k$ where $0 < k < K$, define a possible set of $S_{k,k+1} = (p_k, p_{k+1})$ as follows.

$$ S \triangleq \{S_{1,2}, \ldots, S_{k,k+1}, \ldots, S_{K-1,K}\} $$

For all $S_{k,k+1}$, calculate the transformation matrix $V_{k,k+1}$.
which minimizes the distances between two point clouds $p_k^s$ and $p_{k+1}^t$. The set of transformation matrices is expressed as follows.

$$\mathcal{V} \triangleq \{V_{1,2}, \cdots, V_{k,k+1}, \cdots, V_{K-1,K}\}$$

A series of processes is called as global registration that obtains only one point cloud by performing pose graph optimization using the transformation matrix set $\mathcal{V}$ and the point cloud set $\mathcal{P}$ [9] [8]. And it can be checked through Fig 3. As a result, it is possible to obtain a 3D color map (i.e., one completed point cloud) for the captured image. The Jacobian RGB-D odometry method was used for ICP-registration, and the process of ICP-registration is shown in Algorithm [1].

The tools/libraries used in the experiment are the python 3.6.5, OpenCV 4.2.0, numpy 1.19 and Open3D 1.0.0 [5] [3].

III. VR RENDERING

Three.js is a library that renders 3D images on a website [6]. In addition, it supports image rendering for VR devices, through which WebVR can be implemented. The point cloud can be loaded by through PCDLoader, a built-in function of Three.js that can load pcd file. Then if VRButton, a module that can render pcd file into VR device, is used, it is possible to show point cloud via VR. Fig. 4 represents the result of rendering using Three.js.

IV. CONCLUSIONS AND FUTURE WORK

We showed the process of receiving RGB-D values from Azure Kinect, obtaining a complete point cloud using Open3D, and implementing WebVR through Three.js. As shown in Fig. 3 and 4, the limitation of this paper is that we could not solve the empty space of point cloud. If solving for empty spaces, and if a point cloud with high resolution can be obtained, it presents the possibility of development that can be applied to hologram and light field technologies.

ACKNOWLEDGMENT

This research was supported by IITP grant funded by the Korea government (MSIP) (No. 2017-0-00068, A Development of Driving Decision Engine for Autonomous Driving using Driving Experience Information). J. Kim is the corresponding author of this paper.
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