DEVELOPMENT OF AN IOT-ENHANCED TELEPRESENCE SYSTEM BASED ON SLAM AND VR

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ABSTRACT: The technology of Internet of Things (IoT) allows users to access sensing and tasking capabilities of smart devices via the Internet, which enables various automatic and efficient applications. As users usually rely on the IDs of devices on dashboards or smartphone applications to access these capabilities, users need to be familiar with the device setup and the environment in the first place. On the other hand, telepresence is the concept of providing users feelings of being exist at a remote place. While most Virtual-Reality-based (VR-based) telepresence systems provides visual, hearing, and speaking abilities to users, the ability of interacting with the environment is also necessary for an immersive telepresence system. Therefore, we propose an IoT-enhanced telepresence system based on a remote-control robot, Simultaneous Localization and Mapping (SLAM) and VR. The general steps are as follows. (1) To achieve an immersive telepresence, an omnidirectional camera is mounted on a robot, from which users can see the 360-degree view of the remote environment and control the robot with a VR device. (2) To recognize the locations of IoT devices, the position and orientation of the robot are necessary, which are obtained via aligning the ORB-SLAM2 model with a pre-generated Building Information model (BIM) model that helps indicate IoT devices. (3) Afterward, the real-time 360-degree video and control panels of IoT devices can be rendered in the VR device, where the control panels connect to an Open Geospatial Consortium (OGC) SensorThings API IoT service for sensing and tasking capabilities. As a result, the proposed system provides a more immersive telepresence experience to intuitively interact with the environment via the IoT.

KEY WORDS: Virtual Reality, IoT, Simultaneous Localization and Mapping, Telepresence

1. Introduction

In recent years, because of the COVID-19 pandemic, working from home has become a common lifestyle. The concept of doing tasks and observe information remotely is related to the so-called “telepresence”. From a simple video call to telepresence robot, various sensors help provide telepresence experiences. Recently, some researchers are trying to provide more immersive user experiences by utilizing Virtual Reality (VR) technologies, which enable users to control telepresence robot more intuitively. Meanwhile, with the development of Internet of Things (IoT), embedded devices provide sensing and tasking capabilities. However, users usually rely on dashboards or smartphone applications to access these IoT resources, which is not intuitive. To overcome the aforementioned problems, this research proposes an IoT-enhanced telepresence system based on a remote-control robot, Simultaneous Localization and Mapping (SLAM) and VR.

2. Methodology

The goal of this research is to provide an IoT-enhanced telepresence system based on Simultaneous Localization and Mapping and VR, there are mainly three parts of this research: (1) a telepresence system, (2) a positioning system, (3) an IoT system

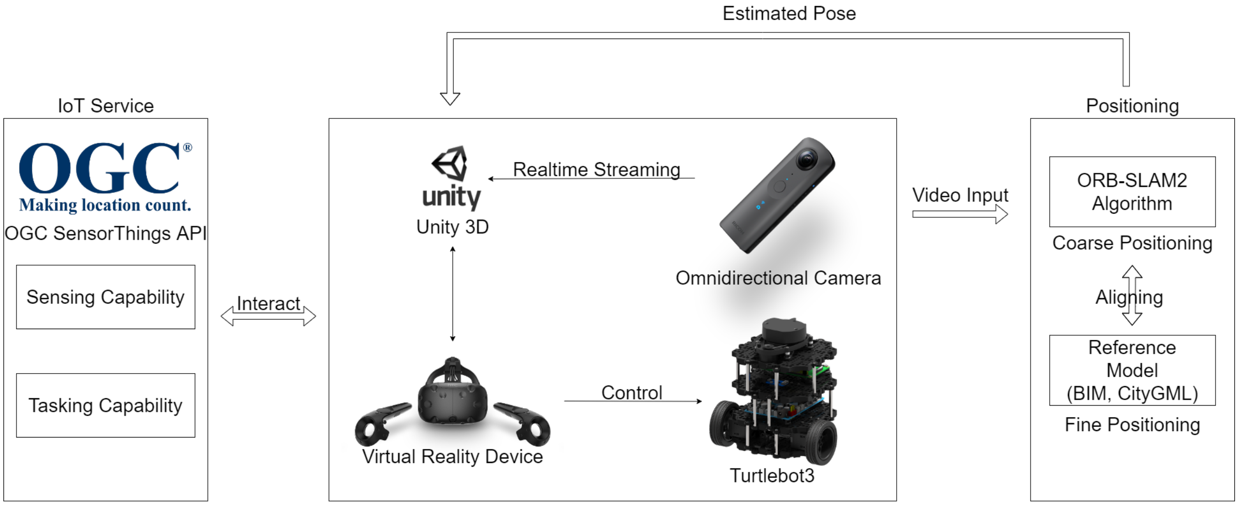

Figure 1. System Architecture

2.1 Telepresence system

In this research, we use Turtlebot3 as a telepresence robot, and we use an omnidirectional camera to capture the surrounding of the robot. To integrate telepresence robot and VR, the view of camera will be stream to a Unity project and display real-time video to the VR headset. Users can control the robot, and the VR headset will keep track of user's head orientations and change the views correspondingly.

2.2 Positioning

For the positioning of the robot, we use the ORB-SLAM2 (Mur-Artal, 2017) algorithm, which is a well-known SLAM algorithm, to achieve coarse positioning. After we obtain the SLAM model, we can align the SLAM model with a pre-generated BIM model (Figure 2), which is a reference model, for a more accurate positioning of IoT devices. The estimated pose will be streamed into the Unity project, and the robot will update its position and rotation in Unity correspondingly.

Figure 2. Aligning the SLAM model with the reference model

2.3 IoT service

To access the sensing and tasking capability of IoT devices, we follow the standard of OGC SensorThings API. Once the telepresence robot encounters an IoT device, user can interact with the IoT device with the VR controller.

3. Result

In the system, users can see the surrounding of the robot with the VR headset (Figure 3), and control the robot. When the telepresence robot encounters an IoT device, users can interact with the device by using the VR controller. For example, when a user encounters an IoT light bulb, the user clicks on the VR controller, and it'll turn it on or off.

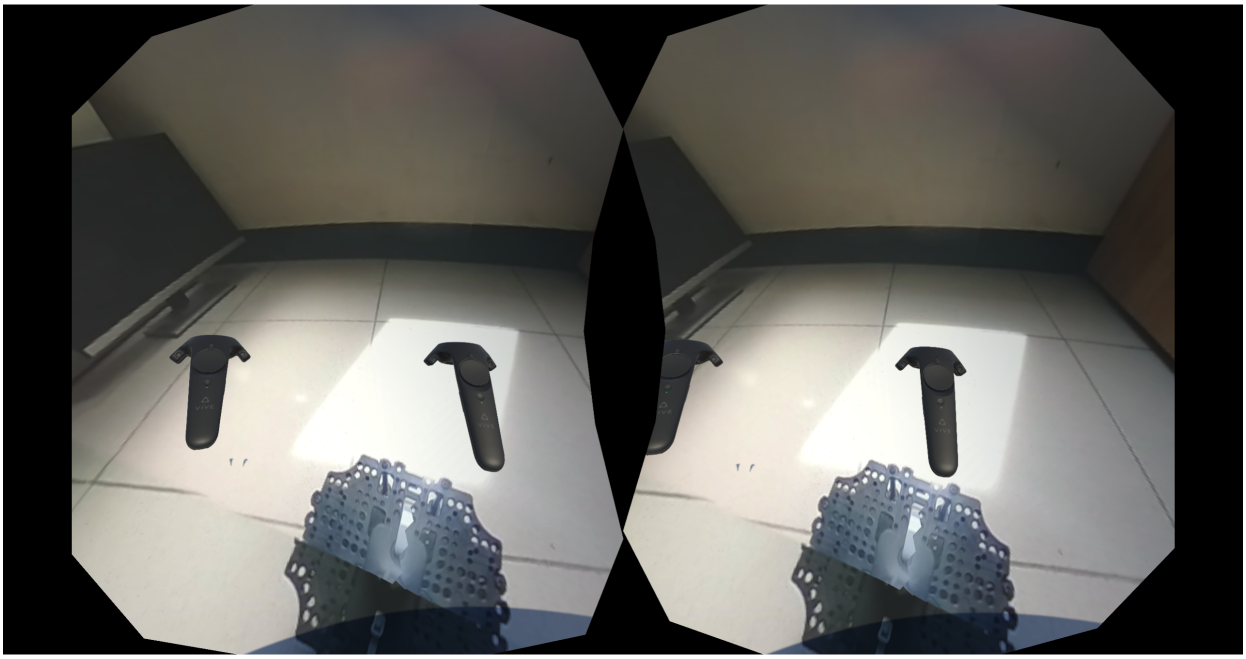

Figure 3. User's view in VR

4. Conclusion

The purpose of this research is to design and construct an IoT-enhanced telepresence system based on SLAM and VR. According to the results, users can control the telepresence robot to interact with IoT device in an intuitive way. For different IoT devices, we can design intuitive ways to control. For example, by rotating to VR controller to adjust the temperature of fridge, timer of oven, brightness of light bulb, etc. This system could be applied to high-risk industries. For example, engineers could control and monitor manufacturing machines while remain safe. For the future work, we will work on the automatic positioning of the IoT devices and also improve the positioning accuracy via the registration between the BIM model and image features.

5. Reference

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