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KINECT MAPPING FOR VIRTUAL NAVIGATION

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Abstract— The foundation for building virtual environments using Kinect mapping is proposed in the abstract of this article. The primary goals of this effort are to construct 3D worlds and an interface that will allow users to move around in those 3D virtual environments made possible by Kinect. Microsoft's motion-sensing input system, Kinect, provides 3D data (depth). We create 3D maps of a room based on the simultaneous localization and mapping (SLAM) concept using that depth data, giving the user the impression that he is travelling through virtual surroundings. This can be achieved by wearing a cap-like head mount with a gyro sensor mounted on it; using the gyro sensor and a certain microcontroller, we can calculate the angular velocities of the human head. The 3D map is virtually moved using these human head angular velocities. So the user can move around in the virtual world. The creation of a multi-agent robot system that can function independently in an outside setting is one of the long-term objectives of this endeavor.

Index Terms— Kinect sensor; RGBDSLAM; feature extraction

I. INTRODUCTION

The capacity to swiftly gather 3D models of the environment and estimate the pose based on those models is required in many applications in the field of robotics and computer vision. A robot, for example, would need to orient itself in the surroundings and plan its path accordingly before it can move autonomously. But numerous technologies, like time-of-flight sensors, stereo cameras, lasers, etc., have developed in order to carry out this operation, which scientists refer to as simultaneous localization and mapping. However, these techniques are either expensive or need a lot of computational power. A whole new approach to this problem was made possible with the development of the Microsoft Kinect. Kinect is a real-time motion capture and depth sensing device that is inexpensive and designed specifically for Xbox game console applications. Utilizing complex algorithms, it is feasible to create 3D environments using the depth information provided by the Kinect.

The creation of these 3D maps serves as the foundation for simulating a virtual environment. Pausch created a system that aids users with virtual reality navigation. His approach encouraged others to consider low-cost solutions, even if the restricted technology at his disposal caused challenges with performance and usability [2]. Others have concentrated on the potential use of the Microsoft Kinect in interactive applications by proposing new techniques for quickly and accurately predicting 3D positions of the human body [3]. By using hand and body gestures, Blanchard et al. have created Kinoogle, a natural user interface for navigating Google Earth [4].

One of the fastest selling game systems in history, the Wii uses tracking through its controller, the "Wiimote," and has grown in popularity not only as a platform for amusement but also for the study of interaction methods [5]. Researchers like [5] and [8] have used the Wiimote in its conventional gameplay setup, which involves holding the remote stationaryly in one hand. He used the Wiimote in this manner to accomplish head tracking without unduly burdening the user [14]. Similar to this, Lee developed a multi-touch interactive whiteboard surface by converting the coordinates of the Wiimote's camera to those of the whiteboard display. Unfortunately, the Wiimote's tracking resolution and quality were limited by its sensitivity to placement and occlusions, as well as other problems that come with using the Wiimote for tracking [7].

Researchers are just just starting to investigate the Razer Hydra, a freshly introduced technology. For instance, Altenhoff et al. evaluated the Hydra as an input device with the goal of controlling robotic surgical systems [13]. However, rather than examining the impact of using the Hydra as an input device, this study concentrated on the impact of stereoscopic vision on task performance. In a different study, Basu et al. combined the iPod Touch 4G sensor system with the Hydra as a second tracking source, and they used the resulting tracking data to enable user interaction with a virtual environment rendered in a head mounted display (HMD) [1]. Separately, Kuntz and Ciger investigated using an HMD and the Hydra for low-cost immersion VR with hand tracking and button-based interaction [10].

However, these two systems still cost about €1000 each, which is a barrier for some users because they require HMDs. Our investigation examines the distinctive qualities and constraints of three particular interaction devices—the Wiimote, the Kinect, and the Hydra—building on earlier research involving low-cost VR technologies. By doing this, we hope that our research will highlight the versatility of these technologies and help others understand them better. In our experience, the Kinect's gesture recognition is not stable enough to handle a complicated interface. The definition of a concise, appropriate, and intuitive gesture library for the Kinect continues to present difficulties for both developers and users [9].

II. MOTIVATION

Since the early 1990s, head tracking has been studied.

Virtual reality technologies have been created to track the user's point of view orientation and for head tracking. The term "virtual reality" is used to describe a three-dimensional, computer-generated environment that can be interacted with by a person and simulates a virtual presence in another location. Virtual reality (VR) has been extensively used in the field of cultural heritage to recreate and explore historically and culturally significant content that is typically not available in other contexts. Optoelectronic sensors, acoustic sensors, and magnetic sensors are three different types of technologies that have already been used for these purposes. Among those trackers, magnetic sensors are most frequently used for navigation. Unlike traditional optical sensors, these sensors offer the benefit of being compact, unobtrusive, and free from visual and spatial restrictions. However, research into these devices led to expensive, high-encumbrance commercial solutions, which limited their potential applications. It's interesting how these kinds of gadgets can play a significant role in a variety of Virtual-Reality-based applications, including tele-surgery, simulators, training, games, art, tele-manipulation, and CAD design. A personal computer can be used to interact with the head-mounted 3 DOF (Roll, Pitch, and Yaw) Virtual Tracking sensor.

III. CURRENT SYSTEM

Time of flight and stereo cameras are the two types of sensors most frequently used for 3D mapping. These current systems have developed their own shortcomings. Either they are expensive or they need a lot of processing power. A whole new approach to this problem was made possible with the development of the Microsoft Kinect. Kinect is a real-time motion capture and depth sensing device that is inexpensive and designed specifically for Xbox game console applications. Using sophisticated algorithms, it is possible to create 3D environments using the Kinect's depth information.

IV. SYSTEM PROPOSED

This inexpensive, lightweight camera with the Kinect sensor allows for 3-D picture capturing, aiding in process improvement through pattern recognition, object tracking, and long-term path planning.

Both vision and depth sensors are present in the MS Kinect. It can record RGB images as well as information about the pixel depth. The visual and shape data from the RGB-D cameras are combined in kinect mapping. Three elements are necessary for 3D mapping, as was already mentioned. The alignment of succeeding data frames, the identification of loop closures, and the full alignment of the data sequence come first. Kinect records a number of frames, from which features are extracted. The other frame is matched with the extracted data from each frame. Each time, the map is updated and maintained and the frames are matched with the other frames. Using the iterative nearest point method, the alignment of data frame issue is solved (ICP). By employing this procedure, iterations are performed from a point in one frame to a point in the next-closest frame. The transformation is calculated, and the separation between them is minimised.

In contrast to conventional operating systems that manage processes and schedule tasks, ROS, an open source robot operating system, offers a structured communications layer on top of the host operating systems of a heterogeneous compute cluster. ROSelectricprovideslibrariesandtoolstohelpsoftwaredevelopersc reaterobotapplications. There are hardware abstractions, device drivers, libraries, visualizers, message-passing, package management, and more available.

I. MAP BUILDING

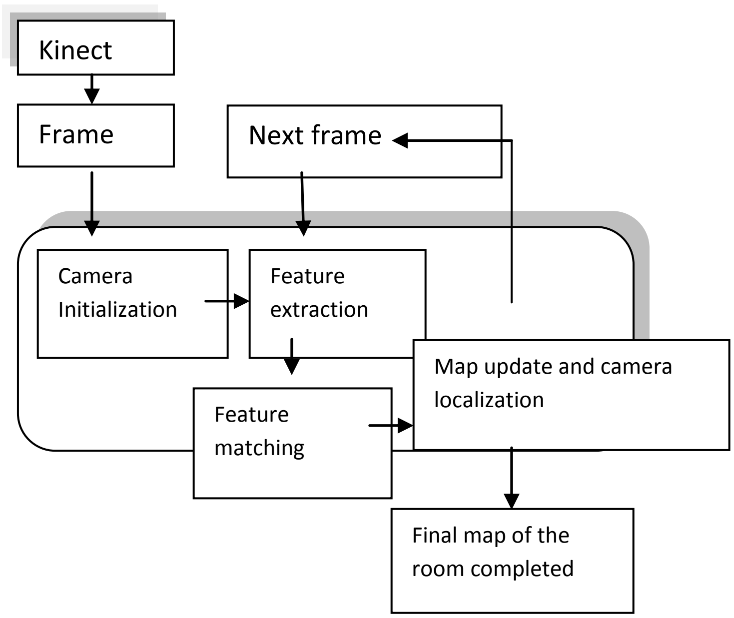

Fig. 1 The algorithm of Kinect mapping

The scheme of the mapping algorithm is shown in Figure1.

First, the camera is initially positioned in the middle of the global coordinate frame, rotating around the negative z-axis. The sparse set of feature points is extracted, and the algorithm outlined in the previous section is used to estimate the new camera position. The information from the depth camera is handled after this phase.

The raw depth measurements are used to compute the 3D positions of points are:

$$Xir = \frac{fxir}{(x-cxir)dm}$$

$$Yir = \frac{fxir}{(y-cyir)dm}$$

$$Zir = dm$$

Where cxir;cyir is the location of the primary point of the IR camera, dm is the depth in metres, fxir;fyir is the focal length, and x;y is the position of the depth pixel in the image. Calibration estimates the focal length and principal point's location. The mapping between a colour image and a depth image can be described by the following equations given the extrinsic rotation R and translation T between the RGB and IR cameras:

$$\begin{pmatrix} Xrgb \\ Yrgb \\ Zrgb \end{pmatrix} = \begin{pmatrix} Xir \\ Yir \\ Zir \end{pmatrix} R+T$$

These 3D positions need to first be translated into the world coordinate system before they can be placed to the map. The transformation can be described by the equation below:

$$\begin{pmatrix} Xw \\ Yw \\ Zw \end{pmatrix} = R^{-1} \begin{pmatrix} Xrgb \\ Yrgb \\ Zrgb \end{pmatrix} - R^{-1}T$$

Where the matrices R and T represent the estimated camera posture and specify how to convert a 3D point from the coordinate system of the camera's real position to the global coordinate system, respectively. The map is examined for overlapping points, which are then combined, and the same technique is applied to each subsequent frame.

VI. IMPLEMENTATION

The Xbox 360 Kinect, which combines a regular RGB camera and a depth camera, is primarily produced for this console. By projecting a highly amorphous IR pattern from the IR projector, depth information is obtained. Figure 2 displays the depth and RGB images.

Fig. 2 Right image represents the Kinect depth image; the black pixels have an unknown depth value, mostly because of occlusion or reflective surface material. The Left image is captured by Kinect RGB camera.

Installing Ros Electric and rgbd slam requirements in Ubuntu is the first step in the complete procedure. We will now begin the mapping using the commands in the Ubuntu console. The map of a room is created with Kinect utilising the mapping technique.

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We can see the depth of each object in a room after the mapping of that room is complete. Our immersion in virtual reality is made possible by this 3D map, which serves as an input to the gyro-equipped head mount cap. As a result, our head movements are used to calculate the angular velocities. The 3D point cloud is initially accessed through mouse motions, allowing for the operation of a 3D map. In order for the user to traverse the map, our programme hacks the mouse motions and substitutes the user's head movement. Figure 5 displays the angular velocities provided by the gyro. Using an Arduino microcontroller, these angular velocities are further translated to Yaw, Pitch, and Roll and interfaced with the 3D map. The mouse movements are substituted by these values as they are interfaced with the 3D map. Yaw, Pitch, and Roll variables can be used to navigate the 3D map without the aid of a mouse.

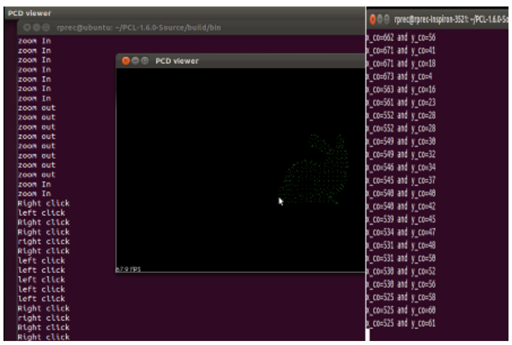


Fig. 3 Screenshot showing the mapping process and stitching of #d frames with one another

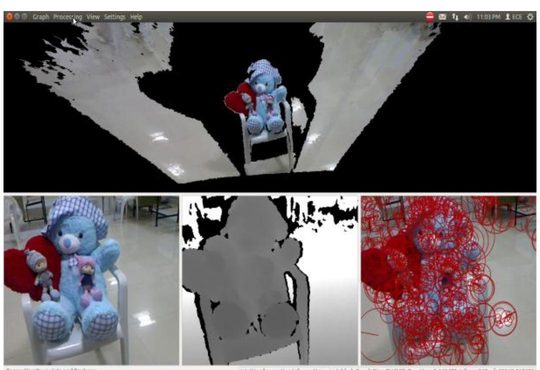
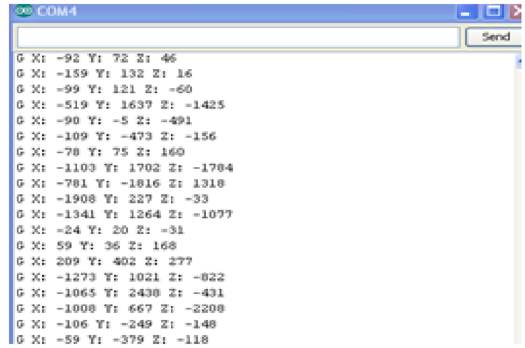


Fig. 4 The top view of a complete 3D map of a room obtained after the mapping

As a result, after recording all mouse movements, we proceeded to replace them with the yaw, pitch, and roll calculated from the angular velocities. For instance, the programme is set up so that when a user sees at an angle of 10 degrees to the right or up, the corresponding movement of the maps is 10 degrees, allowing the user to view the surroundings from the point of his choice.

Finally, the mouse positions were compromised, and Yaw, Pitch, and Roll values were used in their place. As a result, when the user dons the head mount and faces the rendered 3D map, he loses awareness of his current location and identity and enters a world of fantasy, adventure, and exploration.



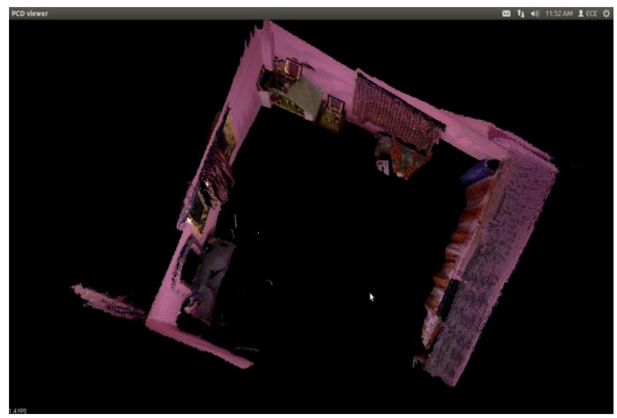


Fig. 6 The top view of a complete 3D map of a room obtained after mapping

VII. APPLICATIONS

Virtual reality research is now advancing significantly. Virtual reality has a wide range of uses. These applications cover a range of industries: The military, which now encompasses all three services, has embraced immersion in virtual settings (army, navyand air force). It is employed to prepare soldiers for combat and other hazardous situations in which they must learn how to react. The business community can utilise it for a variety of purposes, such as training new staff and taking virtual tours of commercial environments. It helps them to test a prototype without having to create multiple iterations, which can be time- and money-consuming. The benefit is that it makes it possible for big groups of pupils to interact with one another and in a three-dimensional space.

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It may make difficult information easily understandable to kids in a way that is enjoyable and simple to learn.

CONCLUSION

the 3D environments and a user interface that allow users to move around in those 3D virtual environments made using Kinect. The simultaneous localization and mapping (SLAM) technique is used to construct 3D maps of a space utilising the depth information, giving the user the impression that they are travelling in virtual surroundings. This was accomplished by donning a cap-like head mount that has a gyro sensor mounted on it, together with the gyro sensor and a certain microcontroller. The 3D map is virtually moved using these human head angular velocities. The user can navigate virtually thanks to this. As a result, 3D maps are crucial for enabling the creation of robot platforms, which are an extension of dynamic settings. Building 3D maps to locate the robot is crucial for autonomous applications. This research contributes to ongoing efforts to create virtual reality systems.

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