Crime Scene Investigation using Mircrosoft Kinect

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Abstract

In this project we have implemented a method for three-dimensional reconstruction of crime scene using the Microsoft Kinect RGB-D which can provide dense point clouds.

1 Introduction

The most important part of investigating a crime is to collect clues from crime scene. The investigating agencies use various methods, i.e capturing the crime scene by photography or 3D laser scanning, investigate and records any clues manually by pen and paper etc. Most of current method are not only manual and requires lot of time but it is also vulnerable to loss of data with time and altering the clues at crime area. The motivation behind the project is to provide more autonomous and secure method of capturing the crime scene which can not be altered. With more autonomous methodology, the possibility of manual error is also reduced.

2 Crime Scene Investigation

The current process of mapping a crime scene is either by videography,photography or not even that in some places.In places where videography or photography is not used a sketch of the scene is made by hand with measurements shown in the diagram itself using measuring tapes,scales etc.In some places an instrument referred to as a **total station** is also used.

These methods are not very precise,time consuming and increases the potential for mistakes.For example the use of a measuring tape at a crime scene where one may need to have a very long measuring tape as he/she might not know how long the distance that needs to be measured, as well as the fact that the tape may clutter and even contaminate the crime scene if not properly used and cleaned. On the other hand the instruments such as total station are bulky and too expensive.

Since the methods are not very precise they may be questioned in the court during investigation. Also mapping the scene in this manner requires personnel specially dedicated for this which is a waste of the manpower.

Taking into account all these current limitations our project aims to automate this process and improve it.

Figure 1: Microsoft Kinect V1 developed for XBOX 360

3 Microsoft Kinect

Kinect is a line of motion sensing input devices that was produced by Microsoft for Xbox 360 and Xbox One video game consoles and Microsoft Windows PCs. Based around a web-cam style add-on peripheral, it enables users to control and interact with their console/computer without the need for a game controller, through a natural user interface using gestures and spoken commands.

3.1 Technology

The Kinect sensor is a horizontal bar connected to a small base with a motorized pivot and is designed to be positioned lengthwise above or below the video display. The device features an "RGB camera, depth sensor and multi-array microphone running proprietary software which provide full-body 3D motion capture, facial recognition and voice recognition capabilities.The Kinect sensor's microphone array enables Xbox 360 to conduct acoustic source localization and ambient noise suppression, allowing for things such as headset-free party chat over Xbox Live.The depth sensor consists of an infrared laser projector combined with a monochrome CMOS sensor, which captures video data in 3D under any ambient light conditions. The sensing range of the depth sensor is adjustable, and Kinect software is capable of automatically calibrating the sensor based on game play and the player's physical environment, accommodating for the presence of furniture or other obstacles.

3.2 Why is Kinect Better?

Compared to the alternative like 3D laser scanners which are used by Crime Investigation department and Police Force, the Kinect is very cheap and easily portable.

4 Proposed Method

1. Use Microsoft Kinect and a Robot to move and rotate for recording data point for the environment. For our project rather than using a robot we record the environment by holding in kinect in our hand and rotating it in different direction.

Figure 2: a 3D map of hostel room

2. The Kinect is connected to a Laptop with ROS and freenect software installed which allows it to interact with Kinect and receive the point data recorded using the kinect.

3. The RGB-D data is then received by an application which was written using Point Cloud Library. The proposed algorithm then combines these recorded point data into a 3D Map using Grid Search and SLAM algorithm.

4. Once the map generation is complete it is saved in Point Cloud Data Format which can retrieved later and visualised using PCD Viewer.

4.1 Working of SLAM Algorithm

Simultaneous Localization and Mapping (SLAM) is an algorithm that allows a mobile robot to form a map of an unknown environment and locate itself within this map. Such an algorithm is useful in any situation where a human wants to understand an environment but access to the environment is limited.

The problem of a SLAM algorithm is that in order to create a map of the environment, the robot's location must be known, and in order to know the robot's location, a map must be created.

In order to implement such an algorithm three pieces of hardware are necessary: a mobile robot, a means to observe the environment and a computer. Of these essential pieces of hardware, the means to observe the environment and the mobile robot is very important.

Figure 3: another 3D map from different angle

Observing the robot's environment can be implemented in several ways. Examples are sonar, monocular cameras, and laser range finders. Laser range finders provide the most accurate observations but are very expensive.

When considering the robot to use,important parameters to consider are ease of use, odometry performance and price.Odometry means estimating the current position of itself just from its movement,a technique known as **dead reckoning**. Odometry performance measures how well the robot can estimate its own position.

This is the outline of the way the SLAM algorithm works: The SLAM algorithm recieves information describing the environment from the Kinect, combines this information with the robot's estimated position from dead reckoning and executes the algorithm.Using the information obtained from kinect and robot and then executing the algorithm it forms a portion of the map and according to the current progress of the map,the computer then sends a motion command to the robot and repeats the algorithm.The main algorithm is executed in a constant loop(i.e. each time after information from kinect and robot is obtained).In this way a complete map of the environment is formed.

4.2 Point Cloud Library

Point Cloud Library is an open source library written in C++ that provide support for working with point data i.e the RGB-D recorded by Microsoft Kinect. PCL API has support for 3D surface reconstruction using kd-trees and different advanced data structure to represent the 3D graph.

3D Construction in PCL works by trying to add point data to the present map created by performing a grid search and finding it's nearest neighbor. The nearest neighbor is identified using minimum least sqaure (mls) points. Once the neighbor is located the new point can be appended to the graph next to it's neighbor. This is a continuous process and keeps happening as new points are recorded by kinect.

5 Software/Hardware Used

- Microsoft Kinect — A motion sensing camera developed by Microsoft for XBOX 360. It has 2 depth cameras and 1 RGB Camera.
- Robot Operating System — It is an open source platform for developing application for robots.
- Point Cloud Library — A C++ library that provide a developer API to work with point data which can be extracted form different Hardware i.e Microsoft Kinect
- Raspberry Pi — Initially as planned we used a raspberry pi to control the Kinect remotely and send generated point to remote machine over WiFi.

6 Use Cases

3D Reconstruction is helpful not only in crime scene investigation but many other field such as:

- Crime Scene Reconstruction
- Autonomous exploration of an environment by a robot
- Development of environments for virtual games
- Military applications
- Underwater exploration
- Mining
- Outer space terrain mapping for a better understanding of the environment.

7 Source Code

The source code for 3D Reconstruction is available at my github repo. The build executable files are also included and hence it can be used by anyone with a kinect device.

8 Further Work

The field of Crime Scene Investigation using Time of Flight cameras like Microsoft Kinect is not deeply explored but is gaining importance. Various aspect of our current work can improved. The point cloud generated can be made more denser by calibrating the Kinect to work better. Algorithm for 3D reconstruction can be improved to give a more dense point clouds.

Automating the process can be done by mounting the kinect to robot and using a raspberry pi which can interact and send the generated cloud to a remote PC over wifi. Initial work in this direction was started but we focused our aim at improving the density of graph.

References

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