Multi-sensor Characteristics and Application-based Processing

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Abstract. *There are three challenges associated with any mobile mapping system: accuracy, robustness, and cost. Considering the above challenges, the student's task is primarily to analyze the possibility of new sensors being integrated into the mobile mapping system. In view of its advanced features, including a gyroscope, accelerometer, 4K RGB camera, and Depth camera, Microsoft Azure Kinect is considered to be a potential candidate. The CamBoard pico Monstar from Pmdtec is another type of depth sensor that is highly powerful and versatile and has a measuring range of 6 meters. We are responsible for characterizing these sensors and determining their suitability for their intended application.*

Keywords. Sensor characterization, time-of-flight camera, depth camera, multi sensor, sensor integration

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1 Introduction

Figure 1. An example of Mobile mapping system

Figure 1 illustrates an example of Mobile mapping system. In general, the following sensors are integrated in a multi sensor system:

- 2D/3D Laser Scanner
- IMU/GNSS unit
- Imaging system
- Mounting platform

The three challenges that come with any mobile mapping system are accuracy, robustness, and cost. In a mobile mapping system, multiple Laser scanners and cameras are usually main exteroceptive sensors. Cameras can provide accuracy result and usually inexpensive, but they are very sensitive to light conditions. Laser scanners of high precision, such as 64-beam Laser scanners, are very expensive. A 2D Laser scanner or 16-beam Laser scanner, on the other hand, is not as expensive, but accuracy is not as high.

Considering the above challenges, it is proposed that new sensors be integrated into the mobile mapping system. In this study, two new sensors are expected to be added to the system.

1.1 Azure Kinect

Azure Kinect features advanced computer vision and speech models, advanced AI sensors, and a range of powerful SDKs [1], including these sensors: Gyroscope and accelerometer, RGB camera, Depth camera, IR emitters, and microphone array.

1.2 Pmdtec Monstar

The CamBoard pico monstar is one of the most powerful and versatile depth sensing system, offering a Field of View (FoV) of 100 ° x 85 ° degrees and pixel resolution of 352 x 287 with a range of 6m, and is powered by USB[2].

2 Sensor characterization and appropriate application assessment

2.1 Using one Azure Kinect: RGB guided IR image reconstruction

RGB cameras have a high resolution, but they are greatly influenced by ambient light when they are used outside. Infrared cameras on the other hand have high noise levels and low resolution, but they are less affected by light conditions. If the advantages of RGB cameras and infrared cameras are combined, outdoor data performance will be greatly enhanced.

The focus of the research is on how to register RGB images and infrared images. It also focuses on the use of Deep Learning for improving infrared image resolution using the information from the corresponding RGB image (Figure 2). Various types of neural networks are used for testing, such as GAN and transformer, which are both well known. As a central concept, a generative adversarial network (GAN) is based on indirect training through a discriminator that is updated dynamically as well. The generative network generates candidates while the discriminative network evaluates them. This enables the model to learn in an unsupervised manner.

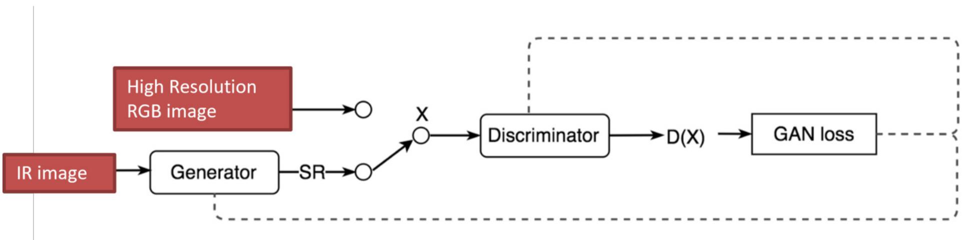

Figure 2. Workflow of RGB guided IR image reconstruction

2.2 Using Pmdtec and Azure Kinect: Sensor synchronization

In the area of multi-dimensional time-of-flight (ToF) depth sensing, Pmdtec is a leading technology provider. Section 1.2 intruduced the basic parameters of Pmdtec Monstar ToF camera.

Considering that Monstar can only generate depth images, it is imperative to integrate other imaging sensors with Monstar. The Azure Kinect solution is a suitable option since it can acquire RGB images, depth images, and IMU data simultaneously. Azure Kinect and Monstar can be integrated to develop a simple-low cost outdoor multi-sensor system (Figure 3).

Figure 3. Integration of Monstar and Azure Kinect

3 Results and discussion

3.1 RGB guided IR image reconstruction

As can be seen from Figure 4, the image generated by the GAN network is smoother than an infrared image, with less noise and a higher resolution when compared with an infrared picture. Additionally, it is less affected by lighting conditions than RGB images.

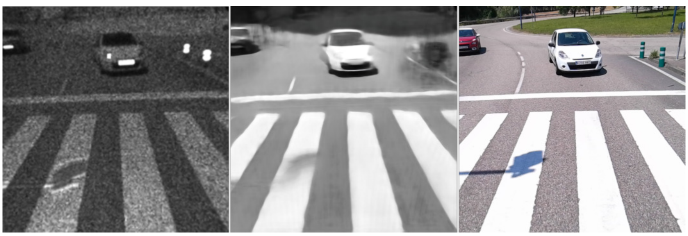

Figure 4. Left: the infrared image; Middle: the reconstructed grey image; Right: RGB image

3.2 Using Pmdtec and Azure Kinect: Sensor synchronization

Figure 5 the interface of a ROS system which subscribe the topics from Azure Kinect and Pmdtec Monstar at the same time. The two sensors are syncronized by the global variable `TimeSynchronizer`. However, these results were not very encouraging. Further research should be undertaken to compress the data volume.

4 Conclusion

The objective of this study was to evaluate the possibility of integrating new sensors, e.g., Azure Kinect and Pmdtec Monstar, within mobile mapping systems. The insights gained from this study may be of assistance for Mobile Mapping applications based on devices mounted on non-dedicated vehicles. This study is limited by the requirement of large amounts of data transmissions and intensive calculations. Continued efforts are needed to compress the data.

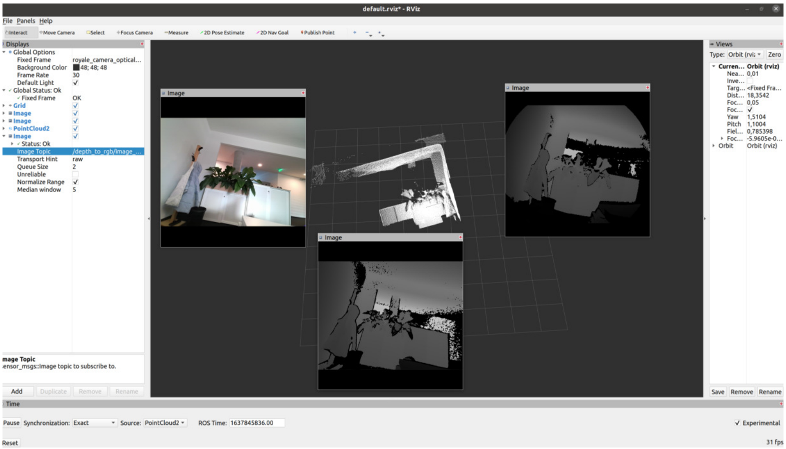

Figure 5. Integration of Azure Kinect and Pmdtec Monstar in a ROS system (In the middle: the generated point cloud)

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