TEST OF A LOW COST VEHICLE-BORNE 360 DEGREE PANORAMA IMAGE SYSTEM

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ABSTRACT:

Recently many areas require wide field of view images. Such as surveillance, virtual reality, navigation and 3D scene reconstruction. Conventional camera systems have a limited filed of view and provide partial information about the scene. however, omni directional vision system can overcome these disadvantages. Acquiring 360 degree panorama images requires expensive omni camera lens. In this study, 360 degree panorama image was tested using a low cost optical reflector which captures 360 degree panoramic views with single shot. This 360 degree panorama image system can be used with detailed positional information from GPS/INS. Through this study result, we show 360 degree panorama image is very effective tool for mobile monitoring system.

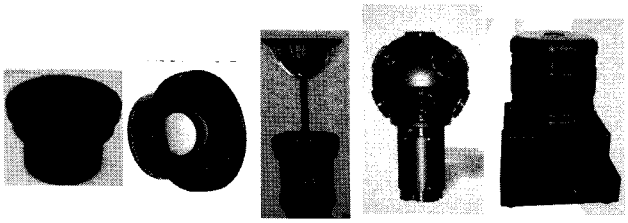
KEY WORDS: DSLR, GPS/INS System, 360 Degree Panorama Image, Catadioptrics, Mobile Monitoring System

1. INTRODUCTION

1.1 Previous work

Omni direction is also called panorama. Panorama comes from the greek phrase "all sight".

Omni directional vision sensors, proposed in 1970, have been studied in Computer Vision and Multimedia researches(Ishiguro, H., 1998). A number of researches are sensor based navigation of autonomous mobile robots, using omni directional image sensors like a fish eye lens, wide angle lens and optical reflector so called catadioptrics with conventional camera. Recently, multi cameras with mobile monitoring system like Point Gray LadyBug2, Immersive Media Dodeca 2360 cameras were developed for acquiring road environment images. Figure 1 shows Omni directional vision sensor and multi camera system.



(a) (b) (c) (d) (e)

Figure 1. Omni directional vision sensor and multi camera system
(a)Fish eye lens, (b)Wide angle lens, (c)Catadioptrics, (d)Immersive Media Dodeca 2360 Camera, (e)Point Gray Lady Bug2 Camera

1.2 Characteristic of Sensors

Fish Eye Lens : It has a wide angle of view of semi-sphere. Low resolution around perimeter of field of view and very severe image resolution.

Wide Angle Lens : Commercially available lens with the widest field of view without radial distortion is 118 degree. It has more or less limited image resolution.

Catadioptrics : Catadioptric is composed of reflective{mirror} and refractive{lens} with high resolution DSLR(Digital Single-Lens Reflex) Camera. This system is very simple and low cost comparing to multi camera system. Table 1 shows feature of planar, conical, spherical, ellipsoidal, parabolic and hyperboloidal mirror. The hyperboloidal mirror is the best for optical systems using normal camera. The telecentric lens brings that projection is orthogonal, but generally expensive and the size is not small(Ishiguro, H., 1998).

Table 1. Comparison Between Various Mirrors (Ishiguro, H.)

Type	Apparatus	Focal Length	Vertical Field of View	Single Center of Projection	Lens Type
Spherical mirror	Small	Short	-90 to 10	No	Normal
Conic mirror	Large	Long	-45 to 45	No	Normal
Hyperboloidal mirror with a small curvature	Small	Short	-90 to 10	Yes	Normal
Hyperboloidal mirror with a large curvature	Large	Long	-90 to 45	Yes	Normal
Parabola mirror with a small curvature	Small	Short	-90 to 10	Yes	Telecentric
Parabola mirror with a large curvature	Large	Short	-90 to 45	Yes	Telecentric

In this study, we chose hyperboloidal mirror, since vertical field of view was excellent and it was very low cost.

Multi Camera System : It is useful to acquire high-resolution omni directional images of outdoor scenes. It requires geometric(inertial and exterial orientaion) and photometric(limb darkening, colour balance) calibration process. This system can obtain a high-resolution image with almost uniform resolution. It is very expensive.

- Immersive Media Dodeca 2360 Camera : It has 11 directional cameras, low resolution of 640×840 pixels and 290 degree vertical field of view(Khan, F., Chapman, M., Li, J., 2007). This system is used for Goole Map Street View images.

- Point Gray Lady Bug2 Camera : It has six 1,024×768 CCDs. It does not have input external trigger such as DMI(Distance Measuring Instrument) signal.

2. STUDY CONTENTS

2.1 Projection of Hyperboloidal Mirror

When catoptrics are combined with conventional lens system, known as dioptrics, the resulting sensors are known as catadioptrics(Hicks, R., A. and Bajcsy, R., 2000). These systems can be used for applications such as robot control, surveillance, and so on. We tested for mobile monitoring system.

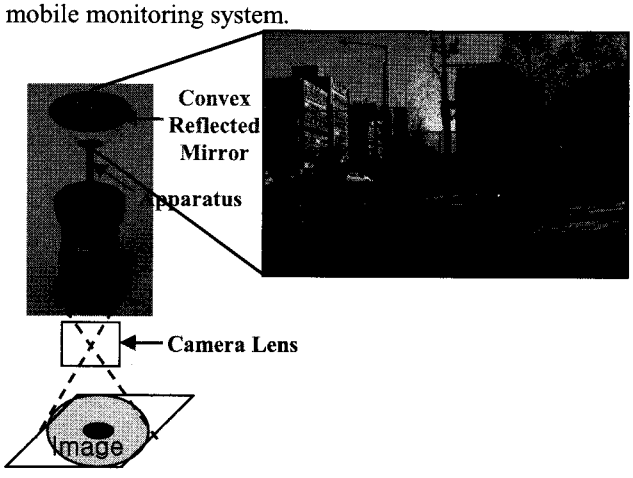


Figure 2. Principal of Catadioptrics System

Figure 2 explains composition of catadioptrics system which consisted of mirror, apparatus, lens and DSLR camera. All directional scene around camera direction can be acquired by one image at the same time.

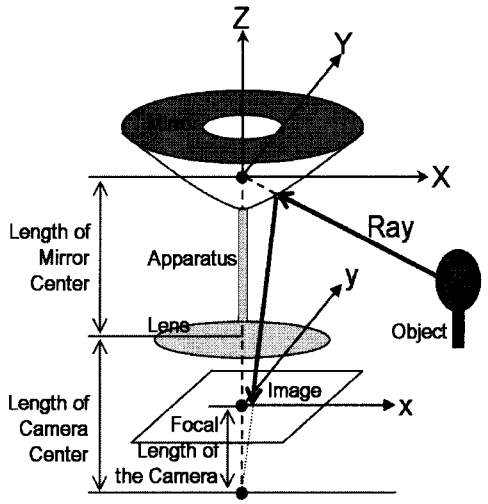


Figure 3. Hyperboloidal Mirror Projection

Figure 3 shows a hyperboloidal mirror projection. The ray which contains object information such as colour, shape, etc are reflected from mirror and passed camera lens and lastly focused on the camera image. We used the polar coordinate system(r,Θ) for image space and the cylindrical coordinate system(R, Θ , Z) for object space. We define the hyperboloidal mirror image as Equation (1) (Yamazawa, K., Yagi, Y. and Yachida, M, 1993).

$$\frac{R^2 - Z^2}{a^2 - b^2} = -1 \qquad (1)$$

Where a: semi-major axes of mirror
b: semi-minor axes of mirror
c : length of mirror or camera center

$$c = \sqrt{a^2 + b^2}$$

2.2 Panorama Image

Figure 4. Wrapped(Original) Image

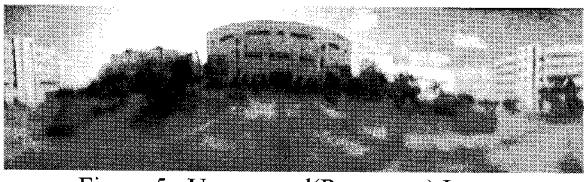


Figure 5. Unwrapped(Panorama) Image

Figure 4 is wrapped(original) image. Small black hole in the center of original image cause form apparatus which connector from mirror to glass in catadioptrics system. Figure 5 is Unwrapped(Panorama) image result and this process is needed hyperboloidal projection(Fig 3).

2.3 Panorama Imaging System

Our system consists of below :

- Mobile Van
- GPS
- INS
- ESD(External Synchronization Device)
- High Resolution DSLR Camera(Canon)
- Catadioptrics(convex reflected Mirror, apparatus) field of view of 360 degrees in horizontal, and from +52.5 to -62.5, totally 115 degrees in the vertical field of view
- Camera Release Controller(Computing Printed Circuit Board, Digital Signal process)
- An uninterruptable power supply

Figure 6. Camera System

Figure 6 shows a display of camera system. DSLR Camera is connected to trigger, computer and power supply. Surveyor can monitor real time image form the DLSR camera's view computer inside van. DSLR camera can operate for long time using electronic power from van and save large images inside DSLR 8GB memory card. DSLR camera acquires images by specific distance for example 1m or 10m using camera release controller signal.

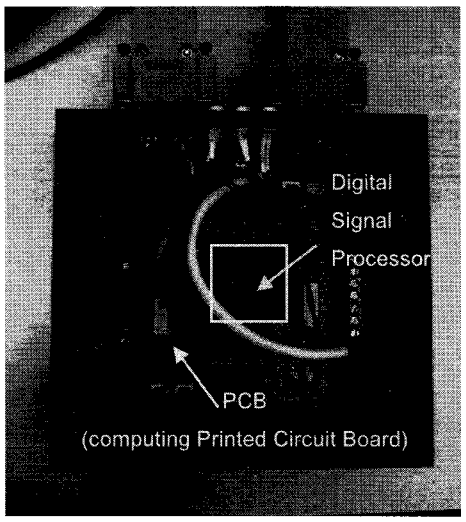


Figure 7. Inside of Camera Release Controller

Figure 7 shows inside of camera release controller which is consisted of DSP(Digital Signal Processor) and PCB(computing Printed Circuit Board). This board and processor send signal of ESD(External Synchronization Device) to trigger signal in DSLR camera.

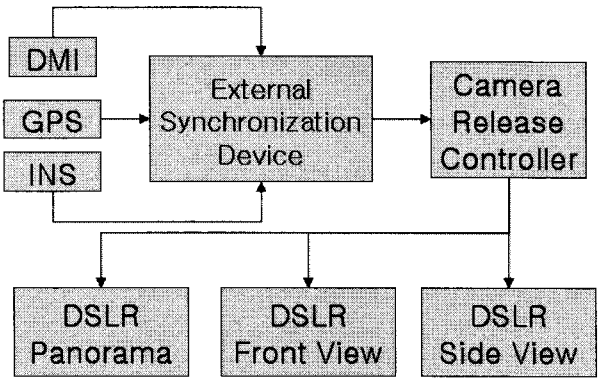


Figure 8. Concept of Panorama Imaging System

Figure 8 shows concept of our panorama imaging system. ESD gathers information of DMI(distance), GPS(position), INS(orientation) and is operated by specific distance. Our system easily can change distance setting. The signal from ESD pass camera release controller and then control acquisition time of panorama, side view and front view camera. Lastly, all camera capture images at the same time without any missing image. After integrating with GPS and INS, very accurate positional information(Easting, Northing, Height) is calculated at all distance.

Figure 9. Mobile Panorama Image System in KICT(Korea Institute of Construction Technology)

Figure 9 shows mobile van system in KICT. Monitor, operating computer, GPS receiver, INS and other sensor are installed in mobile van.

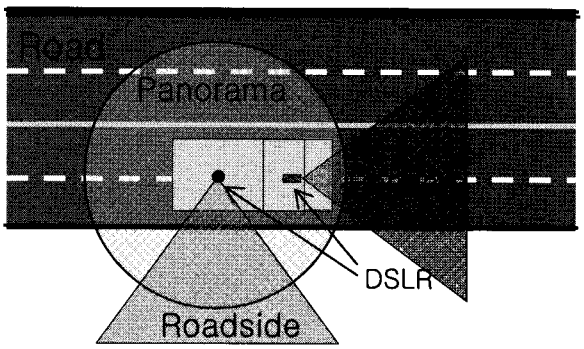


Figure 10. Coverage of Camera's Image

Figure 10 shows the coverage of all camera images. Panorama image is 360 degree coverage but low resolution. To complement this problem, high resolution forward and roadside view cameras were used. Figure 11 shows example of roadside image using our system.

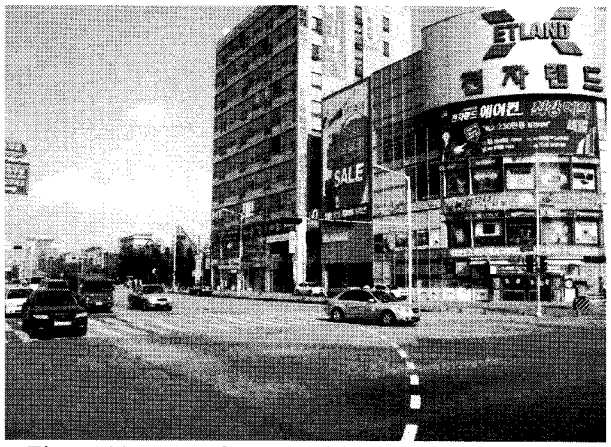


Figure 11. Image form Road Side DSLR Camera in Il-San Area

3. COLCLUSION

Our study has the primary advantage of simple and low cost 360 degree image acquisition system. In this paper, we have studied design of acquiring low cost panorama image system and tested DSLR cameras in mobile van. We tested and showed that accurate positional information and high resolution DLSR image with map can be used for various applications such as contents of map service, navigation, internet service and etc.

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