

RESEARCH ON VEHICLE-BORNE SYSTEM OF 3D SPATIAL DATA ACQUISITION BASED ON POS AND LASER RANGING TECHNOLOGY

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KEY WORDS: POS, Laser Scanner, CCD, Distance Measurement Indicator, Vector Sensor, Data Acquisition

ABSTRACT:

Ground spatial data acquisition is a key technology in digital city engineering, It is important to improve the efficiency of data acquisition. The main purpose of this paper is to develop vehicle-borne system of 3D spatial data acquisition based on POS (Positioning Orientation System), LS(Laser Scanner), CCD camera an so on, the system is also called MSMP(Mobile Surveying & Mapping Platform system). POS is consisted of GPS (Global Positioning System) and IMU (Inertial Measurement Unit), positioning and attitude data is acquired by POS. 3D spatial geometric data is acquired by LS, and texture data is acquired by CCD camera. All sensors are fixed in the car's stable platform in the system, only in this way can guarantee that when the car is moving forward at a certain speed, All sensors are synchronous with movement or posture of platform. Acquiring texture is an important work in this research, this paper proposes a new method of acquiring texture with DMI (Distance Measurement Indicator) and Vector Sensor, which can supply better texture information for digital city construction.

1. INTRODUCTION

Three dimension spatial data acquisition and processing is a key point in surveying and mapping work (LI De-ren, GUO Sheng, HU Qing-wu, 2008). At present, the main data acquisition platforms have space data acquisition platform, navigation data acquisition platform and ground data acquisition platform. In terms of rapidity, flexibility and reliability, ground data acquisition platform is the most effective fundamental geographic data acquisition platform.

With the development and maturity of GPS technology, inertial navigation technology, CCD image technology and laser measurement technology, It is necessary to research on vehicle-borne system of 3D spatial data acquisition and processing, which integrates position attitude measurement technology, laser ranging technology, CCD digital image technology, and so on.

MSMP used in this paper is a vehicle-borne system of 3D spatial data acquisition and processing, the system integrates with differential GPS (DGPS), IMU, Laser Scanner, CCD camera, and so on, Which can get 3D streetscape information acquisition of the city quickly (LU Xiu-shan, LI Qing-quan, etc, 2003). With the continuous improvement of system performance, the system will play an important role in data quick acquisition, such as emergency response decision-making and digital city construction and so on.

2. SYSTEM CONFIGURATION

2.1 System Design

In this research, MSMP uses two kinds of sensors, which includes positioning and attitude sensors and remote sensing sensors. Positioning and attitude sensors include GPS and IMU, they also called POS, which build time benchmark and

coordinates benchmark by GPS. GPS can measure dynamic three-dimensional geographical coordinates of vector, IMU can decide the attitude of vector, GPS / IMU combined navigation can provide accurate vehicle route. Remote sensing sensors include LS and CCD camera, LS can acquire the high-density point cloud map of objects, which is objects' geometry information, while CCD digital camera can acquire digital image information from the same platform simultaneously. Digital image information can provide texture information for three-dimensional building. List of sensors which is used in this research is shown in Table 1.

Sensors	Specification
Laser Scanner	Angle resolution: 0.25° Max Distance: 80 m Max Observation Angle: 180°
IMU	Angular Velocity: ±100,±200,±300°/s Acceleration:±2,±5,±10g
GPS	After-Process Differential: 5 mm + 1 pps Velocity Accuracy: 0.03 m/s (Differential)
CCD	4080×5440 pixels Focus length:35mm

Table 1. List of sensors

All the sensors are tightly fixed on the mobile platform to have

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constant geometric relationship, only in this way can guarantee that when the car is moving forward at a certain speed, All sensors are synchronous with movement or posture of platform. Figure 1 shows the system design of this research. In this system, two laptop PCs are used, the two laptop PCs are synchronized by 1pps (pulse per second) data of GPS. The sensors include IMU, Laser Scanner, Vector Sensor, DMI, CCD, the data acquired by these sensors is sent to two laptop PCs in real time (M Nagai, R Shibasaki, D Manandhar, H Zhao).

2.2 Platform

In this system, the mobile platform is a refitted car, As Figure 2 is shown. In order to doing some measure work by sensors, there is a take-off and landing system which can be controlled in the car. The measure sensors are fixed above the instrument platform. When the experimental measurement is conducted, the instrument platform is raised to the top of the car, when the experimental measurement is finished, the instrument platform can be dropped to the car.

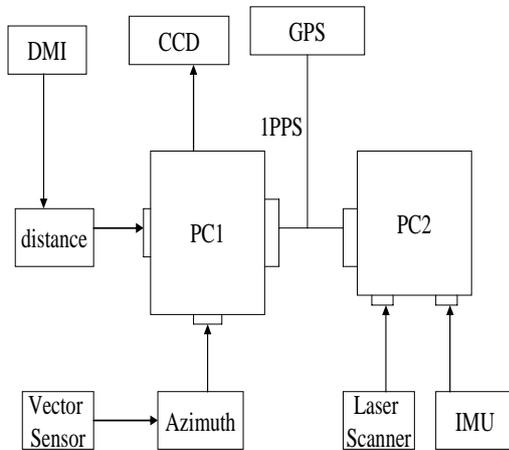


Figure 1. System design



Figure 2. The mobile platform of the MSMP

3. TIME AND SPACE SYNCHRONIZATION

All sensors are fixed on the car's stable platform to establish rigorous geometric relationships. The sensors placed on the platform have different positions, reference coordinate system, in order to know relative position and attitude of every sensor

against POS, it is necessary to calibrate the sensors, which can put all sensors transform to a unified coordinate system(CHEN Yun-fang, YE Ze-tian, etc, 2006). In addition, all sensors are controlled by vehicle-borne computer systems, every sensor has different data acquisition frequency, using GPS time as unified time benchmark, which can realize real-time data acquisition by synchronous controller.

4. DATA ACQUISITION AND PROCESSING

MSMP is a system which integrates some new sensors, in order to represent space in details, it is necessary to acquire 3D shape and texture together, 3D shape is acquired by LS as point cloud data, texture is acquired by CCD sensor, positioning and attitude data is acquired by POS.

4.1 POS Data Acquisition and Processing

POS is consisted of GPS and IMU. GPS is a positioning sensor, the MSMP builds space and time benchmark based on GPS, which can decide the place of the system; IMU is an attitude sensor, which can supply attitude information for MSMP. According to the characteristics of POS, it can improve the position and attitude precision using some sensors' advantage.

4.2 Laser Scanner Data Acquisition and Processing

The system selects SICK LMS291 for the LS sensor, Laser Scanner is an important sensor. 3D shape data of objects is determined by LS as 3D point cloud data, which is different from 3D shape data acquired by three-dimensional photogrammetry. LS can get the objects' digital information in real-time.

4.3 CCD Data Acquisition and Processing

CCD is an important component in this research, which can get texture information of objects, the texture data not only supply detail images information but also texture information for 3D modeling (H Zhao, R Shibasaki, 1999).

In order to acquire integrate image information for a whole scene automatically, a new method which can control array CCD exposure by the distance and azimuth information is proposed. Distance information is acquired by Distance Measurement Indicator (DMI), azimuth information is acquired by Vector Sensor. DMI is a measurement sensor which is developed based on ARM (Zhou Li-gong, 2005), when the mobile platform moves appropriate distance, CCD sensor can get images automatically. Experiments show that the method improves work efficiency.

Figure 3 is the design diagram of CCD control system. The vehicle-borne computer system receive distance and azimuth information in real-time, when the mobile platform move appropriate distance, the control system send pulse by I/O.

4.4 Data Fusion

Sensors have different data acquisition frequency, different work time and different position, in order to integrate sensors, it is necessary to solve time synchronization and space synchronization. In addition, the position and attitude of every laser point and pixel point must be decided by sensors calibration parameters. It can carry out data fusion using above information.

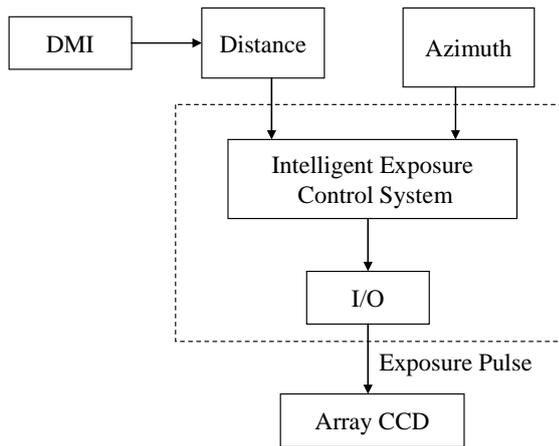


Figure 3. Control CCD design diagram

5. APPLICATION

MSMP makes the best of the technological achievements of the new sensors, such as Laser Scanner, GPS, IMU, CCD and so on, which can get 3D data in city quickly. The system combines laser scanning technology and digital technology with high-precision position and attitude technology, Figure 4 shows the fusion 3D streetscape of POS data and Laser Scanner data. With the continuous improvement of system performance, the system will play an important role in data quick acquisition, such as emergency response decision-making and digital city construction and so on.

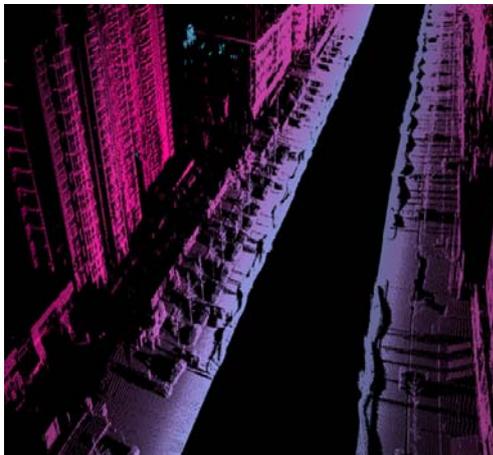


Figure 4. 3D streetscape acquired by MSMP

6. CONCLUSIONS

In conclusion, laser scanner, GPS, IMU and CCD are integrated to acquire 3D spatial data quickly. All the sensors are synchronized with movement or attitude of the platform. Calibration of laser scanner and CCD camera is conducted to know relative position and attitude of each sensor against GPS and IMU. In this paper, all the sensors and equipment are assembled on a refitted car, So MSMP is a reliable, quick method of acquiring 3D data at high resolution.

REFERENCES

LI De-ren, GUO Sheng, HU Qing-wu, 2008. 3S(RS, GPS, GIS) Integration Technology Based LD2000 Series Mobile Mapping System and Its Applications. [J]. ACTA GEODAETICA et CARTOGRAPHICA SINICA, 37(3), pp.272-276.

LU Xiu-shan, LI Qing-quan, etc, 2003. Vehicle-borne urban information acquisition and 3D modeling system. Engineering Journal of Wuhan University, 36(3), pp.76-80.

M Nagai, R Shibasaki, D Manandhar, H Zhao. Development of Digital Surface Model and Feature Extraction by Integrating Laser Scanner and CCD Sensor with IMU [Z].

CHEN Yun-fang, YE Ze-tian, ZHANG Heng-tie , SHI Bo, 2006. Research on mobile data collection system based on multisensor. Transducer and Microsystem Technologies, 25(12), pp.23-25.

H Zhao, R Shibasaki, 1999. A System for Reconstructing Urban 3D Objects Using Ground-based Range and CCD Sensors [A]. In Urban Multi-Media/3D Mapping workshop, Institute of Industrial Science (IIS) [C], The University of Tokyo.

Zhou Li-gong, 2005. Easy ARM7-LPC213x/214x [M]. Beijing: Beijing University of Aeronautics and Astronautics Press.

ACKNOWLEDGEMENTS

This work is funded by state 863 projects (2006AA12Z324).