LD2000 System with 3S and Multi-sensor

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1 Introduction

The market of land vehicle navigation expands very fast and many vehicle navigation systems have been developed in recent years[1]. As we know, digital road network map and road-relative information are integral parts of vehicle navigation system. With digital road network map, map matching and map aiding algorithm can be used to correct measurement drift errors and to snap the computed solution on the road network[2,3]. Basically, there are two methods to generate digital road network maps. One is to scan or digitize paper maps, and the other is to extract road information directly from images of photogrammetry or remote sensing. Although both methods are effective to produce digital roadmaps, the disadvantages of these two methods are also obvious. The quality of available maps is often unknown or questionable and the content is not up-to-date. The use of aerial images as data source may lead to an improvement, but usually at higher expenses.

GPS provides an accurate, effective and flexible approach to create digital road network map. With a car-borne GPS, the trajectory of the car can be logged while the car runs along the road. 5 m differential positioning accuracy can be reached by using cheaper GPS receiver with differential ability. Furthermore, by using carrier phase differential technique, decimeter to centimeter level accuracy can be obtained with a range of several hundred kilometers[4]. This accuracy can satisfy the need of generating digital road map at scale 1:25 000 or 1:50 000. In addition, the road-relative information can also be recorded with the GPS position data to generate road inventory and associated GIS application[5,6].

This paper describes a car-borne road information collecting and updating system (LD2000).
2 System hardware of LD2000

Fig. 1 is the outer photo of this design. Fig. 2 is the inner.

The system is composed of:

- image obtaining sub-system
- differential GPS sub-system
- laser range finder
- odometer, electronic compass (Dead Reckoning System)

Fig. 3 shows the schema of LD2000 hardware configuration. Some main parts of this system are discussed below.

- controlling sub-system
- video recording sub-system
- digital voice recording sub-system
- multi-port communication interface board
- industrial computer
- power unit

Fig. 1 Outside of LD2000

Fig. 2 Inside of LD2000

Fig. 3 The schematic of LD2000 hardware configuration
2.1 The image collecting system

The image collecting system includes three video cameras, a video switch and an image process board. The function of the image process board is to realize the A/D transform. The image sensor of camera is 0.5" frame transfer CCD. A sampling frequency of Hz is obtained by increased clock-frequency and reading only half of the lines of an interlaced image, resulting in a resolution of 288 lines of 768 pixels wide. The cameras are operated with an electronic shutter. This feature provides effective suppression of background light and prevents movement blur in the image. The analog output signal of the cameras is converted to 8 bit image by the image process board subsequently, and the digital image enters computer through PCI bus on real-time. There are two different acquisition programs, one for 2D collection of data (one camera working), which stores data file for post-processing, and the other for real-time 3D reconstruction and tracking (two cameras working), which can either output data to another device or store it on disk. The specifications of cameras are shown in Table 1 and the one of image process board in Table 2.

Table 1 Specifications of CCD camera

| Scanning system | CCIR standard, 625 TV Lines, 50 fields/sec |
|-----------------|-------------------------------------------|
| Image device    | 0.5" frame transfer CCD                    |
| Picture Elements| 800(H) x 600(V)                            |
| Resolution      | Vertical: more than 570TV Lines            |
|                 | Horizontal: more than 400 TV Lines         |
| Electronic shutter| 1/120 - 1/40000sec                      |
| Gain control    | NOR/LIGHT (+6DB)                           |
| Environment     | Temperature: -10°C to 50°C                 |

Table 2 Specification of image process board

| Resolution of image | 768 × 576 |
|---------------------|-----------|
| Computer bus        | PCI       |
| Data of input       | 256×8bit  |
| Windows of collection| User installation |
| Number of input channel| 4         |
| Mode of use         | Plug & play|
| Environment of use  | Dos, Windows, Windows NT                 |

2.2 GPS unit

The GPS receiver is selected under consideration of both capacity and price. The details in the accuracy of positioning, capability of tracing and dynamic feature, etc. need to be checked. Motorola GPS receiver is designed for high performance and maximum flexibility in a wide range of OEM configuration. The Zodiac chip set composed of two custom devices (Digital signal Processor) is used in the highly integrated digital receiver. These two chips combining with suitable memory devices and a minimum of external components form a complete low-power, high-performance and effective GPS receiver solution for OEMs. The main specification is shown in Table 3.

Table 3 Specifications of GPS

| Ability of tracking | 12 satellites |
|---------------------|---------------|
| Dynamic features    | Speed: 950 meters/sec acceleration: 6 g |
| Requisition         | 2 seconds typical with 10 seconds blockage |
| Position accuracy   | Less than ±5 meters (SA off) |
| Timing accuracy     | 0.001 second (1 PPS output) |
| Solution Update Rate| Once per second |
| Time Mark           | Once per second |

2.3 Laser range finder

Leica DATA DIS TO RS232 Laser finder is selected in this MMS. The feature is:
- The cooperate target is needless
- Non-contact, spot-on measurement
With the RS232 interface, not only the DATA DIS-TO can be operated from the computer, but also storable data can be transferred without restriction.
One camera combining with DATA DISTO completes 3D surveying of vertical plate of structure easily. The technical data are shown in Table 4.

Table 4 Technical data of laser range finder

| Typical measuring accuracy | ±3 mm |
|----------------------------|-------|
| Smallest unit displayed    | 0.1 mm across interface |
| Measuring range to natural surfaces | 0.2 m to 30 m |
| Measuring range to target plate | 20 m to 100 m |
| Time for a measurement     | 2.5 s to 10 s |
| Operation temperature      | -10°C to +50°C |

2.4 Odometer and electric compass

Setting up a Dead Reckoning (DR) system that
consists of an electronic compass and an odometer. It may compensate for the shortcomings of GPS position of navigation. The DR system calculates the position of the carrier vehicle by accumulating the velocity and orientation data obtained by the sensors on the vehicle. The DR system is an autonomous navigation system. That is to say, it depends only on the equipment of the vehicle-borne system and thus, it can seldom be affected or disturbed by the surroundings. But because a DR system calculates the position in an accumulation manner, any deviation of the velocity or orientation sensor will bring about positioning an accumulative error that will grow large within a lapse of time. If a DR system is used solely for a long time, the positioning of the system also needs to be combined with the GPS. If the two systems can be effectively incorporated, precise and reliable position data can be obtained. The main technical data are shown in Table 5.

### Table 5 Technical data of electronic compass

| Heading information | Tilt information |
|---------------------|-----------------|
| Accuracy when level | ± 0.5°RUS       |
| Accuracy when tilted| ± 0.1°RUS       |
| Resolution          | 0.1°            |
| Repeatability       | ± 0.2°           |
| Range               | ± 20°            |

### 3 System functions

#### 3.1 Road surveying

Two sets of positioning system are employed as a dual-backup while collecting the position information in the road surveying process, namely, GPS and a combination of electronic compass and the odometer.

#### 3.2 Ground object surveying

Ground object surveying is an important part of the road surveying system. The vehicle road surveying system surveys the 3D spatial coordinates and the relative positional relationships of various kinds of ground object on the both sides of a road. This is accomplished, according to the principle of photogrammetry, by automatic or semi-automatic matching of identical point pairs in stereo photo pairs and building stereo survey models. The scheme for implementing such a stereo surveying system is that a double CCD camera and a Laser Range Finder (LRF) constitute a double-viewed and a single-viewed vision system and can accomplish 3D surveying for point, line and polygon objects.

The matching of identical points is the key process in the surveying of stereo photo-pairs. This surveying system takes automatic or semi-automatic matching measures on epipolar images, and has a high precision and stability. Besides, the precision of the surveying system process depends on the precision of the coordinate of the camera, and the coordinates obtained by Differential GPS Positioning, in fact, suffice for stereo surveying.

#### 3.3 Attribute collecting and recording

Video recording runs through the whole surveying procedure. In the procedure of road surveying, an operator can orient the camera to the sides of road in real-time and then record object information relevant to attributes, such as road names, gas station names, significant building names, etc. In order to locate the road’s spatial position, we define a unique time label to mark the time at which a record is registered into the system. The time label is combined with the record. When indoor data processing operation is performed, object’s spatial position would be obtained from time label and road data. At the same time, replay of the video record can provide a “true road surveying environment”, which will make it convenient for indoor operators to input road attribute data.

Digital voices recording goes with the video recording. Due to the influence of working environment, video recording sometimes is not complete and accurate for road attribute and other attached information. Then we can use digital voice to record attribute data. Considering noises of working environment, the system provides a noise filter. Sound is recorded in the form of files. Every voice recorded has a corresponding ID, which is stored in the system when a new voice record has been collected. When performing indoor data processing opera-
tion, we can find the corresponding voice file according to the voice ID, replay the sound and then input the attribute contained in the voice record into the system.

3.4 Environment data collection

Besides special surveying sensor, sensors for measurement of temperature, humidity, pressure, granularity of floating dust, proportion of various kinds of gases and so on can be installed onto the system to collect environment data.

4 Results of a test database

In the application of LD2000, a road network database of Wunan economic development zone was created. Fig. 4 shows the result from the database. We can produce the digital map of the road network. The digital map includes a variety of information relevant to attribute, such as road coordinate, road width, road name, significant building’s position and name and so on.

5 Applications and expectation

LD2000 has been applied in such fields as automatic vehicle navigation, surveying and mapping of buildings, generation of road measurement network. Besides, LD2000 will have application in many fields, such as highway-mapping, city model plotting, utility mapping, etc. The data acquisition is performed without blocking traffic. The information obtained is diverse—a single collection can be used for multiple purpose.

With the development of communication and compression technology, real-time image data link from field work of mobile mapping to an office can be realized. Such data can be disseminated and accessed through a widely distributed Internet.

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