An Integrated Digital Measuring System for Underground Mine

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Abstract. Surveying is an important work for different kinds of mines, the efficiency and portability of measurement is really very important for underground mine. This paper given a new efficient measurement system named integrated digital measuring system, it consists of integrated measuring instrument, transmission cable, underground portable computer, and aided measurement software, which can be calculate the 3D coordinate real-timely, it could be very useful in mine industry and other field.

Introduction

Mine surveying is an important work of a mine during the period of construction and production. At present, the common measurement methods mainly include mine surveying theodolite, total station, GPS, and even the steel tape or tape etc. With the rapid development of electronic and optical technology, mine surveying accuracy has reached a high level, and formed a relatively complete system of measurement. However, in the practical application process exists some technical problems. Firstly, the measurement process is very complex and time consuming, the work efficiency is very low. Secondly, some instruments are poor portability, and data processing is complex. In addition, it is usually difficult to achieve a full automation [1-5].

In order to improve the technical level and the operation efficiency of mine surveying, and meet the demand of the intelligent mine exploitation, which need an intelligent measurement. An integrated digital measuring system(IDMS) for mine is developed in this paper, with a set of integrated, intelligent, portable, wide applicability and so on characteristics, can be convenient to obtain the mining information.

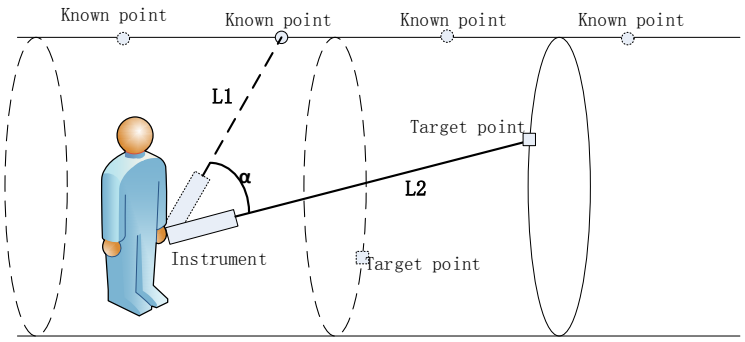
IDMS for mine provides a convenient new technology and new method for underground lane and other spatial structure measurement. On the other hand, the organic combination of the measurement system and the mining process, led to form a new operating system for underground surveying. This system indeed improved the efficiency of mining production and mining process design.

The working principle of the IDMS

IDMS mainly includes the hardware system and measurement software two parts. The hardware system consists of integrated measuring instrument, transmission cable, underground portable computer aided measurement component. The aided measurement software platform includes the communication interface and parameter configuration, the real-time measurement of coordinates, spatial object modeling and 3D display, model analysis and evaluation, intelligent aided measurement function module[6-9].

The working principle of the IDMS could be described in Fig.1.When using the instrument, firstly, make the instrument pointing to a known point, it can calculate the azimuth， inclination angle and distance from the instrument to the known point, and using a specific algorithm can calculate the coordinate value of the instrument. And then taking the coordinate as a foundation, to obtain a new measuring point coordinates by aligning the instrument to target point, meanwhile the distance and

two angle values could be calculated by the following algorithm. In this algorithm the 3D coordinate could be calculated [10-13].



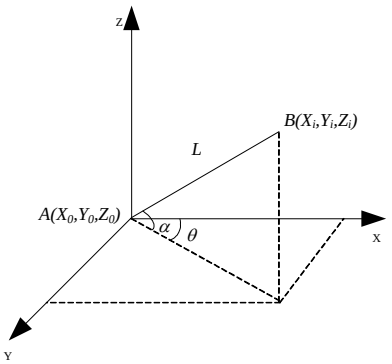


Fig. 1 IDMS measuring process Fig. 2 Calculation of 3D coordinate

The coordinate of a point $A(x_0, y_0, z_0)$ is known, the calculation of any point $B(x, y, z)$ need the dip α and azimuth angle θ between A and B, the specific algorithm as followed.

Horizontal projection: $h = L \bullet \sin\alpha$

Coordinate increment: $\triangle$

Therefore, any point coordinates calculated coordinates:

$$\begin{cases} x_i = x_0 + \sum_{i=1}^{n} \Delta x_i \\ y_i = y_0 + \sum_{i=1}^{n} \Delta y_i \\ z_i = z_0 - \sum_{i=1}^{n} \Delta z_i \end{cases}$$

(x0, y0, z0), known coordinate.

$\triangle$xi, $\triangle$y, $\triangle$zi ,coordinate increment.

$\sum_{i=1}^{n} \Delta x_i$, $\sum_{i=1}^{n} \Delta y_i$, $\sum_{i=1}^{n} \Delta z_i$,the incremental cumulative.

Design of IDMS

The integrated measuring instrument could measure distance, azimuth, dip angle and other functions, and can determine a new point coordinate according to a known point, which is a portable handheld devices. The architecture designed with a high performance embedded processor for processing and control, with a 3.5 inch LCD touch screen to achieve smooth interface graphics operation. At the same time, optimize the application design, and replace implementation complex logic and functional display with the simplest way by prompting function. The casing of the device adopts the humanized design concept, in line with handheld applications.

The hardware circuit design

The measurement of spatial coordinates need the distance, dip angle and azimuth angle. These data can be obtained by high precision laser sensors and electronic compass.

The angle and distance information through a micro controller to realize the integration and processing, and through the network or serial way to exchange data with the upper machine. In additional, also need a controller to fulfill some auxiliary functions, such as data storage, display, sound and light control. A specific way to achieve the circuit as shown in Fig. 3.

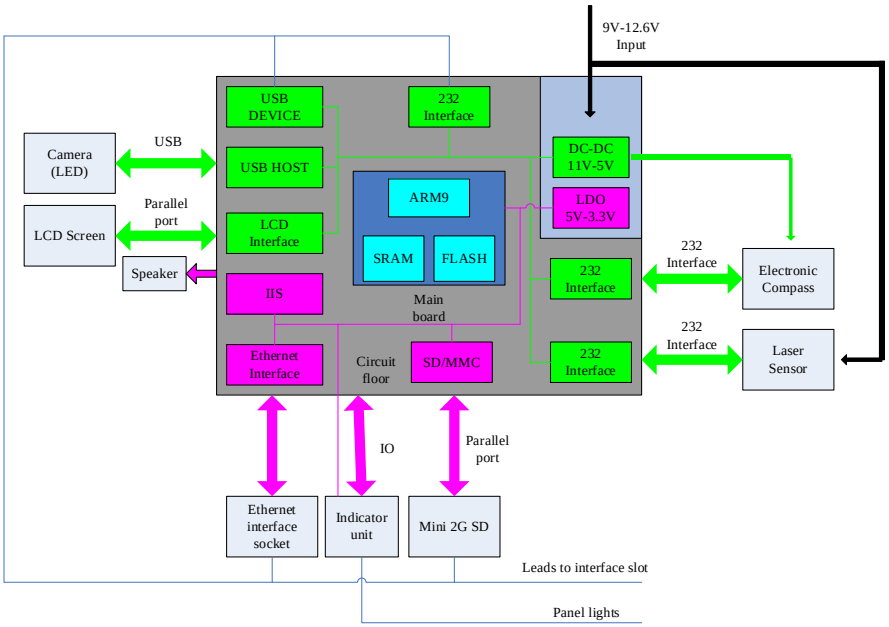


Fig.3 The hardware circuit

The design of mechanical structure

This instrument is a portable handheld device, therefore, we designed a convenient handle, which made of corrugated groove, convenient hand. The inside of the handle is the battery, together with a battery charging interface on the handle.

With a certain inclination angle between the main body and the handle body, the shell is the main function of product line unit, and a collection of various sensors inside. The openings of the front is the laser head and the camera window, and various external interfaces of the products lie in the main shell panel at the end.

The rear panel includes all kinds of interface unit, the indicating lamp unit, power switch, and the interface includes 2 USB interface, 1 network interface, and 1 SD card interface. The position of liquid crystal display panel is placed on the main body, the LCD screen is made into foldable rotating design, make a groove in the position of the panel, the LCD screen is arranged on the inside, when using the LCD screen can be turned into any angle, convenient operation, as shown in figure Fig.4.

Fig.4 Mechanical Structure

Fig.5 The whole parts of IDMS

The structure of software

The software of IDMS including basic functions, such as three-dimensional coordinate's information acquisition, data processing, data storage, data transmission, and with effort of a three-dimensional virtual display platform can achieve the spatial orientation of the measurement object, three-dimensional real-time display, three-dimensional construction and analysis of target object. As shown in Fig. 6

Software consists of application part and measurement part. The measurement part is a set of signal acquisition, data processing and data storage and transmission modules. The main parameters of the measurement include distance, azimuth and inclination, and based on these parameters and the known reference points, the instrument's coordinate can be calculated. Then align the instrument to a target object, and the coordinate can be calculated with distance, azimuth and inclination between the target object and instrument.

The application part can real-time display the point cloud collected by measurement part, meanwhile, get the solid model based on the point cloud, so as to carry on spatial analysis of measured field.

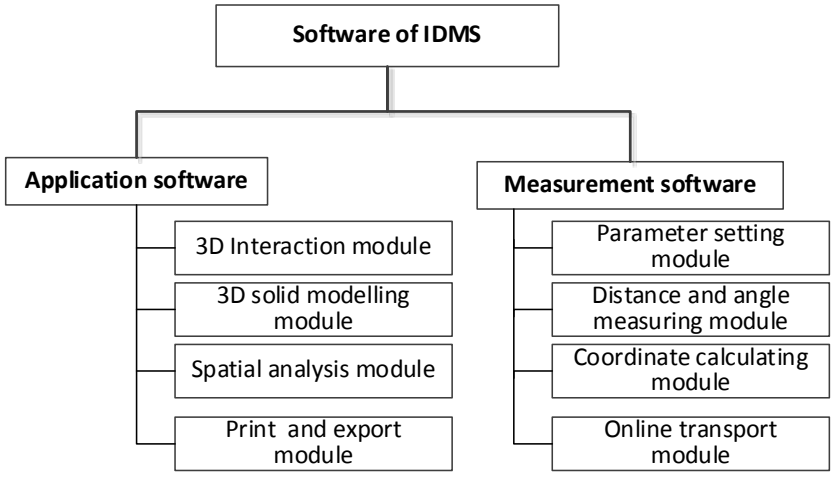


Fig. 6 Structure of software

Industrial Test

The whole parts of IDMS as shown if Fgi.5. And we have carried on an industrial test about IDMS in a copper mine in Hebei Province. The test site was in a lane near a stope, with high humidity, dust, harsh environment, we have tested different parameters in that area. The process shown from Fig.7 to Fig. 9.

Fig. 7 Test at a underground mine

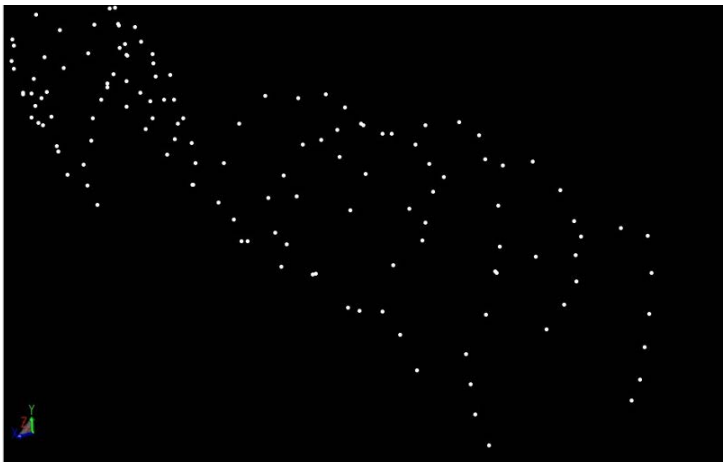


Fig. 8 The point measured by IDMS

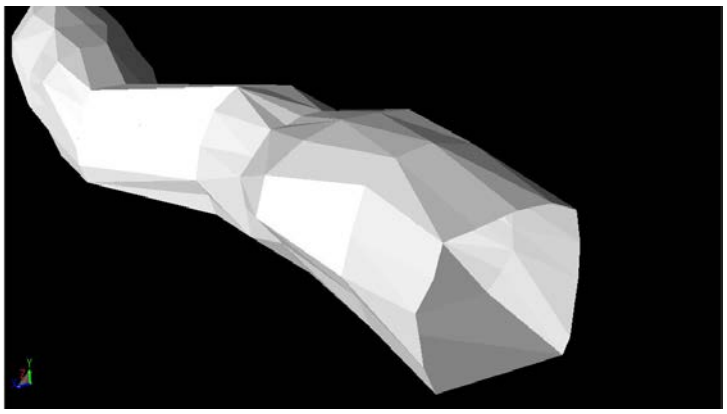


Fig. 9 The solid model of measured field

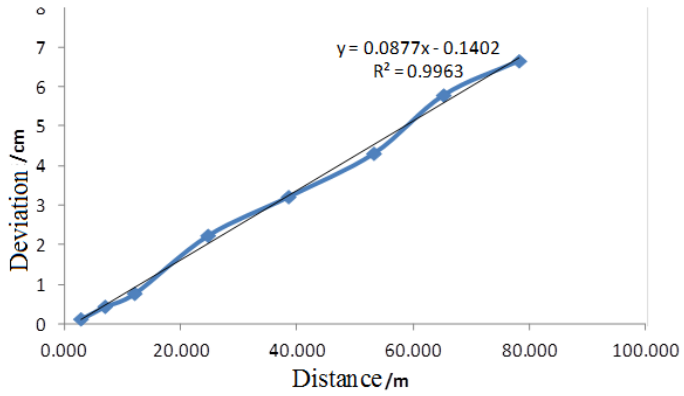


Fig. 10 The accuracy of the distance curve

As shown in Fig.10 the precision of the system is between 0-5cm, less than 10cm, linear degree is 0.9963, with good linearity.

According the test result, IDMS is really a useful instrument which could be used in daily mine surveying, explosion surveying, and other surveying work.

Summary

In this paper, we have given a new measuring system for underground mine, which can be calculate the 3D coordinate real-timely. It could be very useful in mine industry and other field.

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