

# 3D LASER SCANNER SYSTEM FOR SURVEYING AND ENGINEERING

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## ABSTRACT:

For any project, 3D laser scanner system makes sense to deploy the right tool for the job. When as-built, detail, or engineering surveys are required, High-Definition Surveying is the way to go. How to design the system will be described in this paper. The system consists of hardware and software. There are laser scanner unit, CCD camera, control unit and notebook PC (Standard and Enhanced) in the hardware, The software, utilized 3D function of AUTOCAD, under the environment of Visual C++6.0 of MS and OBJECTARX of AUTOCAD, developed application software. It is a software utility for exchanging data between the software modules and AutoCAD (2000 or higher) and MicroStation (SE, /J and V8) software. The system not only offers many benefits to the measurement professional, but to the recipients and users of accurate spatial datasets. Civil engineers, pipe designers, CAD operators, architects, etc. In despite of the system is not all right product, but it has been completed principle experiment and design. The system has been acquired patent in China, 2004.

## 1. INSTRUCTION

### 1.1 What is Technology of 3D Laser Scanner?

3D Laser Scanner Technology is also named "real-scene copying technology", and it can be used as scanning operation in any complex environment or space. It can directly collect 3D data of any large-scale, complex, irregular, standard or non-standard object or scene to computers, and then quickly rebuild 3D model and cartography data such as line, surface, body and space. Also, the 3D Laser point cloud data can be post-processed (such as mapping, measure, analyse, emulation, simulation, display, inspect, VR and so on). It's the most effective way to quickly get the data of the observed object. While working with it, users can build 3D model with 3D Laser Scanner and analyse the 3D scene. The users can view the observed object such as buildings or other elements through different view orientations, so that can get the design effect, compare the harmony with that of other buildings. The users can also try moving the buildings or other emulation effects by man-machine interface, and can reflect your own view in your design, and feel the effect after modified. This makes 3D Laser Scanner System a useful tool in design, plan and construction.

### 1.2 Technology of 3D Laser Scanner in our world

The technology of 3D Laser Scanner brings mapping field new technology space, and leads a new development direction, so that more scholars and businessmen recognize its importance and become interested in it. In recent years, a lot of corresponding technologies and products have come out. Nowadays in the world, many corporations and research institutions cast a lot of financial and manpower to do research on the technology and to develop the system, and get their own corresponding products. The cyrax system produced by American Leica CYRA Corporation and the MENSİ system produced by France are both more prominent in every engineer fields than others internationally.

- a) Leica Cyrax2500 3D Laser Scanner emits laser pulse to the object, scans the measured area, and acquires quickly the 3D coordinates and reflex intensity of ground scene. You can build a 3D model using Cyclone3.0, and get 3D images and measurable points array data of ground scene, and can acquire graphics products that can be easily translated to a lot of output formats.
- b) 3D Laser Scanner products of MENSİ series are developed and produced in MENSİ Corporation in Paris in France in 1987. It's said that this corporation is keeping ahead in the world, and its kernel technologies have achieved 3 international patent protections. Its main products include 3D Laser ultrahigh precision scanner system of KREON series (close distance), MENSİ -S10/S25 3D Laser Scanner system (medium distance), MENSİ GS 100 3D Laser Scanner system (long distance), MENSİ GS 200 3D Laser Scanner system (long distance), and so on.

### 1.3 Application of 3D Laser Scanner Technology

3D Laser Scanner system can be used to scan any object or real scene, so that the users can collect 3D information of ground objects and data modelling, as is especially fit for irregular large-scale object or real scene. Its application area involves cultural relic, archaeology, architecture, spaceflight, aviation, shipping, manufacture, war industry, military, petrification, medicine, water conservancy, energy sources, electric power, traffic, mechanism, film, teaching, scientific research, motorcar, police and so on. Because of its uniqueness and high-quality craftwork of the SOISIC (hardware) and 3SIPSOS (software), we can also find its usage in the modelling, copy, imitation, repair, retread, analysis, reconstruction, maintenance and making archives of the observed objects; the simulation, training, emulation, VR, drilling, test which are applied in task; detection, metamorphosis analysis, CAD, CAM, CMMS, finite element analysis, hydrokinetics analysis, reverse engineering and so on.

## 2. 3D LASER SCANNER SYSTEM PRINCIPLE AND DESIGN

### 2.1 3D Mathematics Model

The author acquired 3D coordinates of object points by laser distance measuring and scanning. Firstly, we build a right-hand coordinate system, whose origin is set at the point where the two axes of control platform intersect, and Z axis is parallel to laser distance measuring line, while X and Y are subsequently set by right-hand coordinate system. Having known that the distance between the origin of the scanning equipment and any point on the surface of measured object is L, and it's given that the vertical scanning step angle of control platform is b, and the horizontal a. Shown as in Fig1, the coordinates of M in O-XYZ coordinate system is expressed in formula 2-1-1.

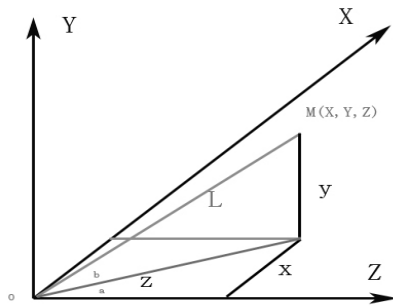


Fig.1 reference frame

$$\begin{aligned}
 Y_i &= L * \sin( b ) \\
 X_i &= L * \cos( b ) \sin( a ) \\
 Z_i &= L * \cos( b ) \cos( a )
 \end{aligned}
 \quad \text{Formula 2-1-1}$$

### 2.2 Components of the System

Laser Scanner System consists of hardware and software. Hardware System mainly includes Laser Distance Measuring Instrument, Step Motor, CCD camera and computer interfaces. Software System mainly includes interface software, application software. Fig 2 shows the structure.

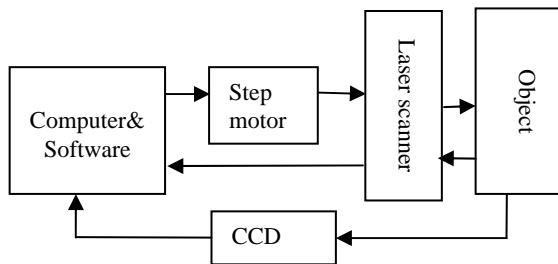


Fig 2. System Framework

### 2.3 Hardware design

We used Leica DISTO Pro laser distance as the laser distance measuring instrument in this experiment. Its precision reaches 1.5mm, and its measuring range exceeds 100m, and it can measure directly integrated with interior memory or be operated with computer. Step motor adopts open loop control, and the laser scanner head is fixed on a control platform which is vertically and horizontally flexible.

### 2.4 Software design

During the development of the software system platform, the author used AutoCAD 2002 authorized by ArtoDesk Corporation as developing platform, and developed a software platform of Laser Scanning System, using its secondary development extended LIB, ObjectARX; using this method, we can make use of the powerful graphics drawing and editing functions of AutoCAD to draw graphics and edit the results, and we can also get more realistic 3D models and 3D scenes after editing and modifying the results built by scanned data using the functions of 3D modelling of its own. Secondary-developing using AutoCAD, we can firstly avoid the complexity of graphics development, to get more stability and usability; and secondly we can also set down the final graphics data format of Laser Scanner System, and make the acquired data more standard so that can meet the international criterion.

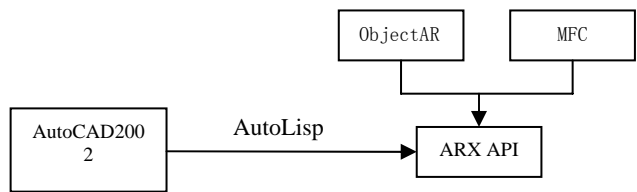


Fig 3. software frame

## 3. RESEARCHED RESULT

### 3.1 System Configuration

Based on all the theories and methods, the paper designed independently a 3D Laser Scanner System, and its basic configurations are shown as follows:

Processor Manufacturer: Intel

Processor Class: Pentium 4

Processor Speed: 1.5 GHz

Installed Memory: 512 MB

Included Drives: 3.5" 1.44MB Floppy, CD-ROM

and Drive Capacity: 40 GB

CD-ROM Read Speed: 48 X

Screen : 17 inch monitor

Leica DISTO Pro laser distance

CCD camera

Control platform

Windows 2000

Visual C++6.

AutoCAD 2002 and ObjectARX

Fig 4 shows the system outline:



Fig.4 system outline

System this paper described can get expected result, and the hardware design is proved feasible. The existing problems mainly come down to step motor and control platform, and these need a further research.

References from websites:

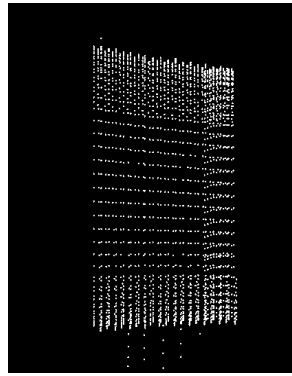
<http://www.leica.com>

<http://www.mensi.com>

### 3.2 Result

To test the hardware and software design theory, I made a scanning experiment with the document cabinet in my workroom.

Fig 5 Shows the scanning result:



Object scanned

Discrete points acquired by scanning



3D modelling in AutoCAD

Fig. 5 experiment Result

From the figures above, we can see: the results of scanning can well describe the basic shape of the objects, but because of the long scanning interval (this system interval is longer than 0.6mm), the shape detail of the object can't be expressed, and there exists some redundant points. We can get the conclusions according to the experiment results: the 3D Laser Scanner