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TERRESTRIAL LASERSCANER

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Abstract

In this paper presents new methods for measuring the three-dimensional position of objects with a very high speed embedded in a sensor measurement called LST or Laserscaner land with high resolution and very good accuracy of the 3D positions of object points only few millimeters. Object space is bale beam columns or lines, points so measured in their entirety forming as so-called cloud points.

Keywords*: 3D measurement,laserscaner, land measurement, cloud points.*

INTRODUCTION

From the point of view of the measurement principle of the LST may be viewed as a polar measurement, which distance is measured with a laser beam, is similar to the total station to measure with a reflector. In contrast however, the LST is not scoring points bezel object, but make a record fully automated raster form surrounding objects without required reflector (Neuner, 2007).
Laser scanning is a new geodetic technique, which can be measured through fully automatic (more or less) the geometry of a structure without a reflective environment, with high precisio)n and high speed (Neuner et al., 2004).
The measurement result is represented by a lot (significant) points, called INL specialized in literaturare ***cloud points.***
Until now it was once generally accepted definition regarding tools (measuring instruments) that can be considered 3D scanners. Because different technical principles are used to measure the elements needed to calculate the 3D coordinates of a number of special know tried to define 3D scanners from other instruments based on their own practical way of operating.
This view, among other disadvantages, leading to unnecessary and pointless discussion if 3D scanning and photogrammetry belongs geodetic measurements. For the user, otherwise, the result is the only that matters, regardless of the method used to obtain it.
From his point of view, a 3D scanner is any device that collects the 3D coordinates of the surface of the land or of an object:
- automatically and in a regular pattern;
- with a rate/high frequency (hundreds or thousands of points per second);

The scanner may or may not deliver the scanned surface reflectivity values as the 3D coordinates of additional training.
Current laser scanning technology can be classified into two categories: static and dynamic. The most common method for determining the distance to an object or surface is laser pulse method.
Similar to radar technology that uses radio waves, the distance is determined by

measuring the difference in time between pulse transmission and detection of the reflected signal.
LIDAR technology has application in geology, seismology, remote sensing, atmospheric physics, etc. Another definition for LIDAR include ALSM (Airborne Laser Swath Mapping) and laser altimetry.
The acronym LADAR (Laser Detection and Ranging) is often used in military context. The term is also used laser radar but this term should be avoided because it can create confusion because it uses laser beam or radio waves.
Static laser scanning is defined where the scanner is installed in a fixed position during data acquisition. Advantages of this method are found in preciziar ide results in relatively high density of points.
Laser scanners are still found under the name of terrestrial laser scanners, but there is a clear demarcation between the two concepts. For laser scanning dynamic laser scanner is mounted on a mobile platform.
This platform can be a plane (laser scanning routes) or a moving vehicle. (Neuner et al., 2004). These systems are much more complex and costly, because it works most often in combination with additional positioning systems (INS- Inertial Navigation Systems), (GPS-Global Positioning System).
Terrestrial laser scanner records the three-dimensional points by measuring the horizontal and vertical angle and distance for each spatial point. Distance measurement is electro-optic, in most cases by the process pulse or phase comparison, according to the type of instrument.
Through the use of simple trigonometric functions are obtained coordinates in a cartesian coordinate system's own scanner.
Horizontal and vertical angle are changed automatically with predetermined intervals. (Neuner et al, 2004) .
Recently new instruments have been introduced in the field of surveying that are able to acquire portions of land and objects of various shapes and sizes in a quick and cheap way. (L. Bornaz, F. Rinaudo,2002).
These instruments, based on laser technology, are commonly known as terrestrial laser scanners.
While laser scanner instruments based on the triangulation principle and high degrees of precision (less than 1 mm) have been widely used since ‘80s, the TOF (Time Of Flight) instruments have been developed for metric survey applications only in the last 5 years. These type of laser scanners can be considered as highly automated total stations.
They are usually made up of a laser, that has been optimised for high speed surveying, and of a set of mechanisms that allows the laser beam to be directed in space in a range that varies according to the instrument that is being used.
For each acquired points a distance is measured on a known direction: X, Y and Z coordinates of a point can be computed for each recorded distance-direction.
Laser scanners allow millions of points to be recorded in a few minutes. Because of their practicality and versatility, these kinds of instruments are today widely used in the field of architectural, archaeological and environmental surveying. (L. Bornaz, F. Rinaudo,2002).

MATERIALS AND METHODS

As mentioned before terrestrial laser scanners can be considered as highly automatic motorised total stations. Unlike total stations however, where the operator directly chooses the points to be surveyed, laser scanners randomly acquire a dense set of points.
The operator only selects the portion of the object he wishes to acquire and the density of the points he desires in the scan (usually the angular step of the scan in vertical and horizontal planes can be selected by the operator). Once these initial values have been choosen, the acquisition is completely automatic.
The result of the laser survey is a very dense points cloud (also called DDSM – Dense Digital Surface Model). For each point of the model the X, Y, and Z coordinates and the reflectivity value are known.

As this set of points is acquired in a completely arbitrary way, with the exception of the parameters imposed by the operator, it is necessary to manage this data in a critical and reasonable way.

Particular attention must be paid to the quality of the original data (L. Bornaz., F. Rinaudo,2002).

The laser scanner data treatment consists of a set of actions that are necessary to obtain the correct digital model of the object, starting from a set of point clouds.

This set of actions can be divided into 2 different stages:

-the pre-treatment (or preliminary treatment) of the laser data;

-the solid modelling of the point cloud.

As "preliminary treatment" we mean all the operations thatare directlycarried outon thepoint cloud, such as, for example, the data filtering (noise reduction), the point clouds registration and georeferencing operations.

The result of these procedures is a complex "noisefree" point cloud (without outliers, gross and systematic errors) and this is the correct starting point for the second stage of the treatment of laser data: the 3D modelling.

The second partof the laser scanner data management, the 3D modelling, is a set of operations that, starting fromany point cloud, allowsa surface model of the object to be formed (L. Bornaz; F. Rinaudo, 2002).

While there is a huge range ofdifferentproducts on the market to carry out solid modelling, just few software for a correct preliminary treatment of terrestrial laser scanner data can be found.

A classification of LST has achieved so far by the principle of measuring distances in surveying applications requiring the principle of impulse and the phase. There are also special distance to the object.

The parameters as scanning speed, maximum distance to the object to be scanned and precision distance measurement, are determined mainly based on the physical principle used to measure distance. In this regard it may be noted that scanners measure the distance on the basis of impulse registered objects at distances much larger than those based on the principle of phase (Neuner,2007; Rabaud,1999).

To compare different products LST, it is also proposed to technical specifications:

- resolution of points scanned at an angle expressed spatial unit number of points/ /steradian;
- beam divergence with respect to the size of the light spot at a certain distance;
- precision 3D form measurement error;
- Scan rate expressed in number of measurements/second. These parameters are required preformed when results scan be statistically analyzed to derive an accurate indicator. In order to achieve the different indicators precision are currently time-consuming calibration, accurate indicators recommended by producers is geared more to the advantageous properties of the sensor. (Neuner, 2007).

Depending on the angle of view (FoV) LST can be classified into three classes:

• scanner type recording chamber;

• scanner wide and hybrid scanners.

Type recording chamber scanners are unable rotation around the main axis of rotation, having a predefined angle of not more than 50 x 50 º. Their field of universal use is restricted, being used especially in works where desired, recording single objects with low spatial expanse. Radius laser scanning object space is cleared of the two rotating mirrors their axes of rotation perpendicular to each other (Neuner, 2007; Rabaud, 1999).

In contrast, hybrid scanners are limited only to the vertical field. To register objects it measures vertical profiles continue executing a rotating scanner head stepping around the vertical axis, provided by a servo-motor. Scan range (Field of View - FoV) is general 360 º x 60º.

The laser beam is transmitted perpendicular mirror shape polygonal rotatable around a horizontal axis and deviates the beam space. Thus he rises to a vertical projection segment (Neuner, 2007). Scanning laser consists of a laser beam deflection through a mirror (by bale or rotation), the reflection of the laser beam on the surface of the measured object and receiving reflected laser beam (Neuner 2007; Rabaud, 1999).

Table 1. The clasification of the Land laserscaner depending on the measuring principle

Measuring principle	Measuring the distance by the principle of phase	Measuring the distanceby the principle of momentum
Measuring range	< 80 m	< 1500 m
Measuring precision	< ± 5 mm	> ± 5 mm

Compared to measure distances using a reflective environment, the accuracy of measurement in this situation depend on the intensity of the reflected laser beam (figure 2) functional relationship between precision and intensity are described by the laws of physics (Neuner et al., 2004). The measuring principle was described and is represented in (Figure 1).

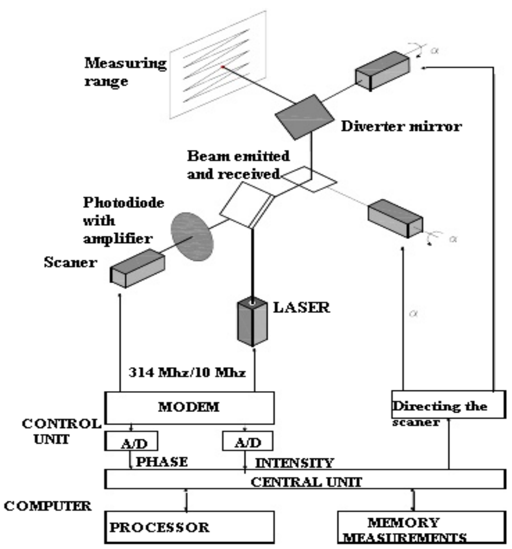

Figure 1. Terrestrial Laser Scanning Principle (Neuner et al, 2004)

The main parameters in this function are the distance from the scanner to the object, the angle of incidence and the reflective properties of the surfaces.

A terrestrial laser scanner, stationary, implies a complex mechanism to measure the two directions of a certain object space.

These lines can be considered to be vertical or horizontal. This principle is suggested in (figure 3). The light beam is emitted by an electronic unit (A) and meets the optic (D), which rotates with very high speed .

On the surface of the optical medium (which has the properties of a mirror) the laser beam is reflected and propagates in a specific angle (ς). When the scanner during the whole profile of the object space, the top of the scanner (C) is rotated by a small angle (α) around the vertical axis, in order to start browsing a different profile, adjacent to the first (Neuner et al., 2004).

The operation is repeated until the completion of all profiles predetermined object of space investigation.

The combination of rotating optics and moving mechanisms of the reflected laser instrument provides the ability to create a uniform network (grid/grid). The measuring principle was described and is represented in (Figure 3).

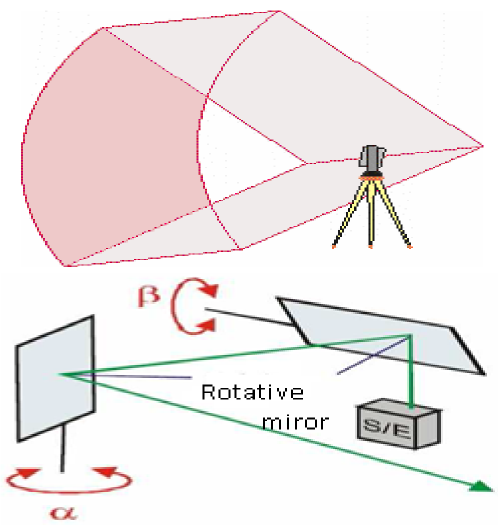

Figure 2. The principle of operation of the scanner type recording chamber (Neuner, 2007)

Description of an object surface is performed by a greater number of points taken (measured), the distance between the points (grid size) may be of the order of millimeters to centimeters. Resolution, or the dimensions of the grid of points describing the surface of an object can be on the order of millimeters panal inches, depending on the position of the instrument (the distance between the points of the station and the object to be scanned), and the inclination of the object surface to the direction of scan.

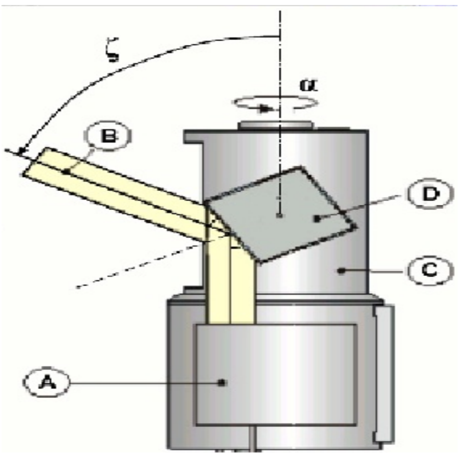

Figure 3. Measuring. Principle (Neuner et al, 2004)

It is important to note that these coordinates are as an internal reference sistem defined by (x,y,z) of the instrument, which the, through georeferencing can be placed in an external coordinate system (X,Y,Z), where necessary (Neuner, 2007).
Compared with records, photogrammetric resolution is much lower, for which there is a tendency to combine the two techniques pickup mass points.
The accuracy of the determination of the spatial position of the points may be on the order of millimeters.
The 3D cartesian coordinates of each measured point are provided through measuring distances, the horizontal and vertical angles.
Most times, with geometric character information (determining 3D coordinates) are provided records of point cloud intensity (radiometric information) and with a built-in photographic camera wich can get a photo of the space object (figure 6).
In this case we can speak even one LIDAR (Light Detecting And Ranging) remote sensing technology defined as optic through which measures properties of scattered light to find range and/or other information about a distant target.
Determination of polar coordinates is accomplished through the laser beam emitted by the device being reflected from the object and measure the distance ,direction and intensity of light reflected in to space. The principle of LST wide was explained and schematic representation can be seen above in (figure 5). In conclusion, we can say that terrestrial laser scanning is a high-resolution spatial data method for geometric patterns (2D or 3D) data for accurate measurements (Neuner et al, 2004).
The hibrid scaner was described above and can be seen in the (figure 4).

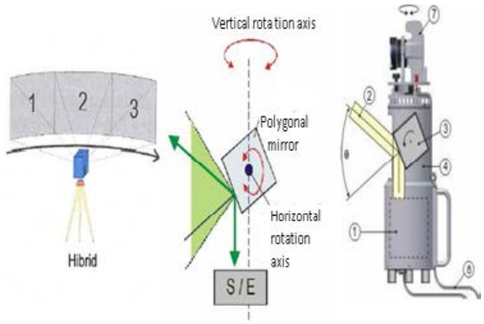

Figure 4. Hybrid Scanner - Riegl 2005 (Neuner, 2007)

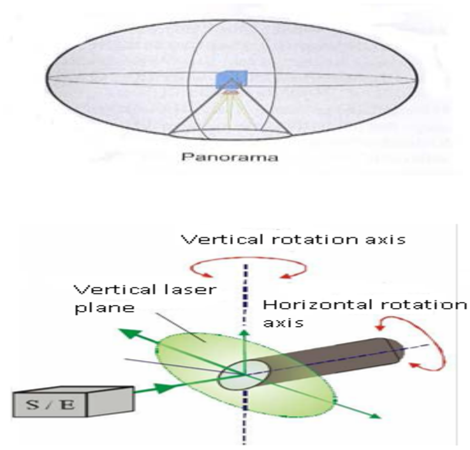

Figure 5. Principle of LST wide(Neuner,2007)

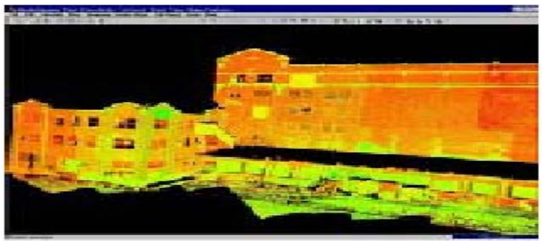

Figure 6. Cloud points with information on the intensity (Neuner et al, 2004)

RESULTS AND DISCUSSION

Panoramic scanners provides a full rotation of the head scan around the main axis of rotation. They have a working vertically almost to complete which is limited only by the bottom surface of the installation tool, to the scanners scanning field (FOV) is 360º x approx. 270º. The laser beam is transmitted horizontally on a surface of a mirror which is inclined at 45 ° to

the horizontal axis of rotation of the mirror. (Neuner, 2007).
This produces a vertical projection plane where is the laser beam. In addition, the
mirror plane is rotated about the main axis. These scanners can be all of the objects recorded in a single scan (Neuner, 2007; Rabaud, 1999).
The notion of " 3D measurement systems " refers to devices that succeed to provide the position, shape and trajectory of an object. The schematic representation can be seen in the (figure 7).
A classification of these systems can be carried out according to the size of which is intended to be registered (position, shape, or path), depending on the physical principle of measurement used (optical or mechanical) function the type of geometric sizes are used (triangulation, trilateration, or hyperbolic method), or the characteristics of the object on which are measurements (eg topography, building facades, car parts, etc.) (Neuner, 2007; Rabaud, 1999).
An important area of measurement technique is to determine position in the kinematic regime. In this case the trajectory of an object is described by a time-dependent position vector and defined in a coordinate system appropriate choice (Neuner, 2007).
Essential in determining kinematic trajectory but the frequency is to be determined by the position of objects to describe as accurately route way.

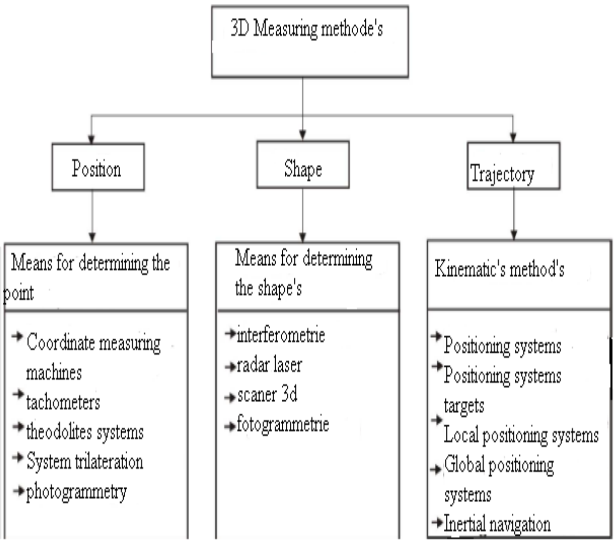

Figure 7. 3D measurement metods (Neuner,2007)

The frequency is in turn dependent on the speed of movement of the object and precision that is required.
Another characteristic of the process description kinematics could be considered the degree of automation measurement depending on the category of sensors used and the methods of measurement used supported in turn by electronic data recording and processing.
For this point of view, it can make a new classification based on the position of the sensor if it is mounted on the object to be measured or outside it (Neuner, 2007).
All systems use a tighter or wider sense methods for measuring angles and distances.
They can be viewed in close about coordinate systems on which they rely. To this end the apparatus measuring coordinates are only an embodiment of a system for the three-dimensional cartesian coordinates where the coordinates x, y, z are obtained directly from the sensors for measuring the lengths. This can be seen in (figure 7) and is explained above in the text
The tahimeters for example is a embodiment of a spherical coordinate system with angles φ, ω and radius polar R, these quantities are measured directly by the instrument (Neuner 2007; Rabaud, 1999).
The Coordinate systems used in 3D measurements can be seen in the (figure 8)

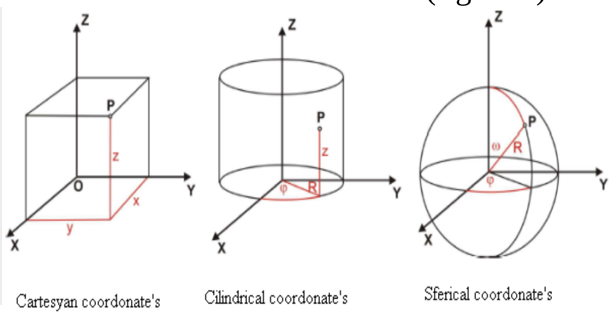

Figure 8. Coordinate systems used in 3D measurements (Neuner, 2007)

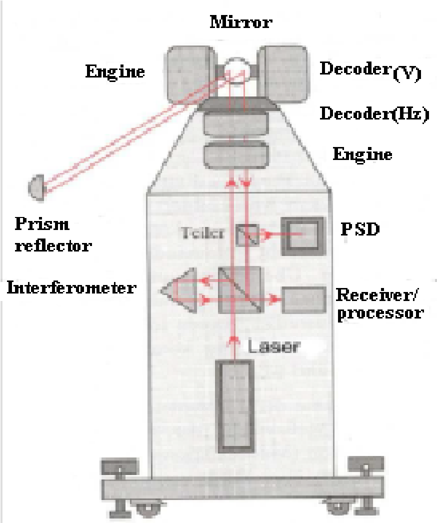

Figure 9. Laser Tracker SMART 310 (Neuner, 2007)

A kinematic measurement system that can track a moving reflector is the SMART 310 manufactured by Leica. Schematic representation of the main components and can be seen in (figure 9)

A laser beam first passes through an interferometer, reaches the rotary dumper mirror and is being diverted to a reflector.

After reflection on the reflector, beam radius reaches back to the interferometer and interferes with the reference beam.

About 70 % of the light reflected by the reflector is directed toward a separating cube in interferometer, which measured changes in reflector distance. The remaining light is directed to a position sensitive diode bright spot (PSD).

Assuming that the beam is reflected in the center reflector, it will get all the PSD center.

A lateral movement of the the prism will lead to a lateral shift of the light spot on the PSD.

Deviations x and y on PSD is a measure of the transverse displacement of the prism to the laser beam.

These is used to calculate signal values of the correction motors (Hz and V), directing mirror roto-tipper so that that beam to drop again reflected center and deviations from the PSD becomes zero.

In this way the laser beam seeks light within certain values. Camera receiver and the system's coordinates are fixed, calculating corrections can take place through the transcalcul coordinates.

The sensor provides two angles (Hz and V) and variance of distance on a reference position of the object space.

These measurements are obtained in polar coordinates, that can be transformed into rectangular coordinates.

These will be initialized at the beginning by routine measurement guidance, as interferometer measures only changes, the distance shall be measured from the beginning at reference distance.

In this sense one could mount a prism in a fixed position even the instrument, the distance position even the instrument, the distance to the primary rotary axis VV instrument being determined by calibration (Home- Point). Another possibility would be to measure a known distance in object space (Neuner, 2007).

CONCLUSIONS

All polar geodetic measuring systems have the disadvantage that do not allow the kinematic measurements than conditioning.

This is due to the time required measurement angles and distances.

In industry and construction sites, however, are increasingly required kinematic measured frequency, which has led to the development of sensors that respond to these requirements.

Terrestrial Laser Scanning is quite legitimately starting to take a larger stake in the domain of mainstream land surveying.

This technological advancement is similar in significance for the industry to what RTK GPS was doing a decade or so ago, and it seems only logical that over the next decade 3D scanning technology will evolve into a main stream tool in the arsenal of most land surveying organizations.

This paper overviews some typical uses where Terrestrial Laser Scanning is changing peoples perceptions of the complexity, accuracy and efficiency in which spatial data can be captured by the modern surveyor.

The use o terrestrial laser scanners for the survey of architectural and natural objects is the most promising techniques in order to achieve quick and complete 3D information.

The data coming from the laser scanner instruments can not be used without a correct approach.

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