Optoelectronic system to position large objects in space

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We present a development from our Laboratory, together with its start-up Q-Tech s.r.l., concerning an optoelectronic system for the accurate positioning, in a semi-automated way, of large objects in space (scenes, buildings, theaters, open spaces). The system operates at distances from 0.5 to 300m, with positioning repeatability of 25mm and maximum error of the measured distance of 10mm.

1 Introduction

The system specifications required the telemeter to operate at very high frequencies (up to 400 kHz), and the need to contain the costs while installing four units on the portal led to the concept of distributed telemeter, where a single unit containing the transmitter optics, receiver optics and control electronics feeds multiple scanning stations through fibre optics pairs. The use of fibre pairs for transmission and detection allows to place the remote measuring stations at distances of 50-100m from the main unit, which can be positioned in a well-shielded shelter far away from train and environmental disturbances.

2 The optical setup of the system

The optoelectronic system is composed of two optical distance measurement systems (telemeters) with high accuracy, each mounted on a 2-axis rotation stage.

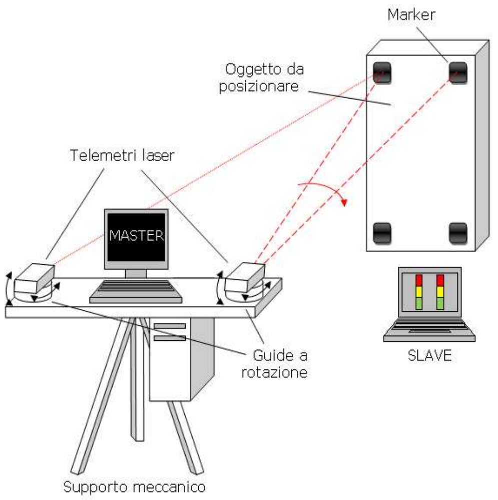

Fig. 1 *Overall layout of the system for positioning objects in space*

The two rotation stages are mounted at a known and calibrated distance onto a rigid aluminum rail, in turn fixed onto a stable tripod. The tripod, in turn, is inserted in the scene.Fig. 1 shows the overall architecture of the system.

Two PCs control the system, operating in a master-slave configuration and connected wirelessly. The master PC controls the system, being interfaced to the rotation stages for position control, and to the telemeters to acquire distance information. The master PC runs a proprietary CAD, to create, edit and manage simple 3D objects and scenes. It also allows to handle more complex objects and scenes created by sophisticated commercial CADs and imported in the familiar STL format. The slave computer is a small, portable PC, held by the operator who carries the objects and is encharged to position them into the scene. The slave PC runs the positioning software.

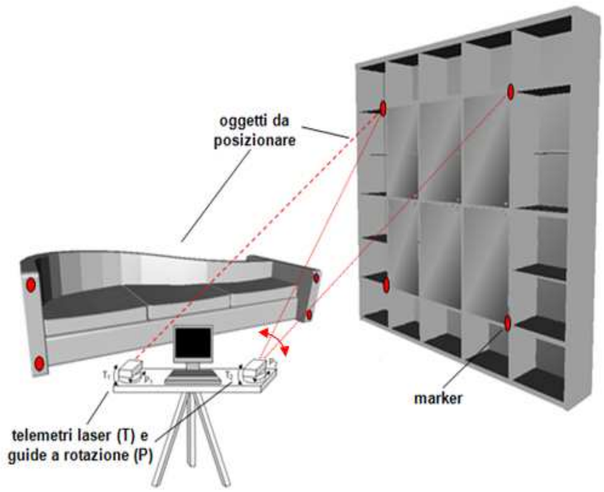

Fig. 2 *Outline of the objects and of the Markers*

The system makes use of a combination of triangulation (to visually assist the operator during the positioning process) and laser telemetry. At the beginning, the system is calibrated (i.e., the relative positions of the rotating stages are defined) by means of a procedure operated in the master PC. The second phase of the operation is the so-called geo-referencing of the calibrated instrument inside the scene. This procedure is also quasi-automatic, and is performed by measuring the distance of suitable scene markers placed at known positions in the scene.

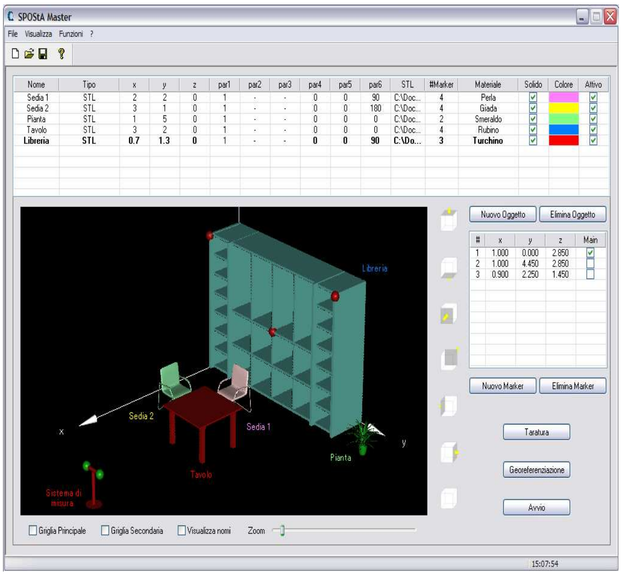

***Fig. 3** Definition of objects in space in the Master PC*

The operator selects the object from the library, and starts the positioning procedure. Firstly, the primary marker is positioned. To do this, the system drives the rotation stages in order to make the laser beams of the two telemeters superimpose exactly at the position in space where the primary marker should be placed.

***Fig. 4** Definition of objects in space in the Master PC*

The operator places the primary marker of the object in correspondence to the superposition point, and checks on the computer that the position measured by the telemeters matches with the desired one. The operator, during this procedure, is also assisted by sound patterns. Small adjustments are finally made with the assistance of the display information on the slave PC.

Once the first marker is in place, the positioning of the other markers begins. In this phase, the first telemeter remains on the primary marker, whereas the other is sent to the marker under consideration. The operator is assisted in the positioning of the marker, to avoid misalignments of the primary marker. This procedure is repeated until all markers are correctly positioned. At the end, one of the telemeters performs a scan of all the markers, to ensure that all of them are positioned in the right place.

The overall specifications obtained with the system have been summarised in the table below.

Laser Pointer	
Measurement range	5 cm ÷ 50 m
Measurement Accuracy	≤±10 mm
Laser	visibile
Class	≤2
Rotators	
Maximum Speed	~15°/s
Repeatability	~500 µrad (~1'43")
Resolution	~15 µrad (~3")
Overall system	
Min. positioning distance	1,5 m
Max. positioning distance	50 m
Typical spotsize at max. distance	30 mm
Max. distance between telemeters	1.5 m
Positioning repeatability	25 mm
Max. error on measured distance	10 mm

Table 1: Overall specifications of the system.

References

[1] L. Fumagalli, P. Tomassini, M. Zanatta and F. Docchio: "A 400kHz, high-accuracy laser telemeter for distributed measurements of 3D profiles" Submitted to IEEE Transaction on Instrumentation and Measurements (2009).

[2] L. Fumagalli, P. Tomassini, M. Zanatta, and F. Docchio, "Laser Telemeter for Distributed measurements of object profiles". Italian patent (submitted)