A LOW-COST LASER SCANNING SYSTEM DESIGN

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Abstract:

In recent years, developments in technology and the advancements in the computer area have become an important part of our daily lives. The increase in the popularity of personal computers after the 90's opened doors to various new innovations. User interfaces have turned computers into tools not for only computer scientists, but also for the ordinary people. This situation provides the means for the development of new software, and increases the demand, which eventually leads to lower production costs. Through the advancement of computer processors, processing of 3D graphics have become faster. Consequently, users started seeing 3D graphics more freuqently, and have become able to produce their own 3D graphics.

At this study, a low cost triangulation-based laser scanner has been designed to produce 3D model data. On a specially designed test object, accuracy and operation of the system is verified by comparing the data output of the laser scanner with the terrestrial photogrammetric method, and the geodetic method. In addition, to provide an example for the outcome model data of the system, some objects, such as sculptures, were scanned, and the resulting data were displayed.

Keywords: Laser Scanning, 3D modelling, Virtual reality models

1. INTRODUCTION

In recent years, advances in computer technology, personal computers and graphics processors has empowered, as a result of this situation use of 3D models either in science or among the end users has become widespread. With the increasing demand for 3D models, high costs of point-based laser scanners and difficulty in processing the data obtained from these devices, has led to the development of low-cost alternative 3D scanning methods. [1]

1.1 DAVID Laser Scanner

DAVID laser scanner is a free software for three-dimensional laser scanning developed by Dr. Simon Winkelbach Simon, Prof. Sven Molkenstruck and F.M. Wahlis. System consists of a computer, video camera, a background containing control points and a line laser source.

1.2 Triangulation Laser Scanners

Getting 3D information from structured light is based on the principle of triangulation. According to the triangulation method, it becomes possible to calculate the 3D coordinate of point (c), if the length

(d) between laser source and camera and the two angles of the triangle is known. **Fig(1)** Magnitude of the (γ) angle affects the depth resolution. If the magnitude of (γ) increases, depth resolution increases as well. [2]

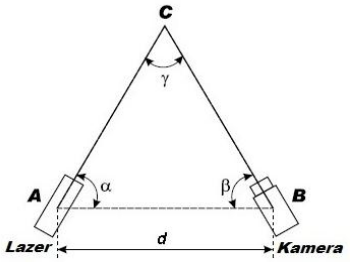

Figure 1: Triangulation

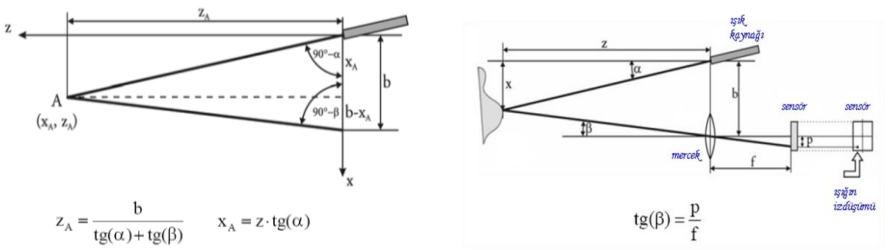

Figure 2: Principle of triangulation

1.3 Laser Calibration

The basic principle of triangulation based systems discussed in the previous section, is that determination of the beam space, which is formed by camera, laser source and the object, as mathematically and establishment of the relationship between image and object coordinates. Thus, new 3D point coordinates can be calculated with the help of mathematical expressions. A background **Fig (4)** which has control points on it is employed at DAVID laser scanning system to establish the relationship between image and object coordinates. The laser ray, expanded to a plane by a cylindrical lens, has to intersect two things at the same time: the (unknown) surface, and the a priori known reference geometry (usually the background). The visible intersection with the background is used to calibrate the laser, i.e. to calculate the exact 3d pose of the laser plane E_{Laser} **Fig (3)**. Detailed information can be found at [3]. On the other hand, the camera should be calibrated. In this software, the calibration of the camera is done with the in [4].

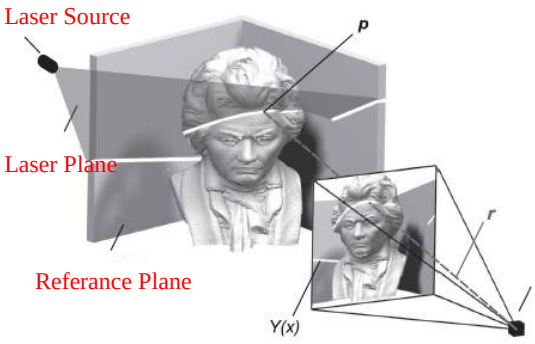

Figure 3: Laser triangulation: 3d scene and 2d camera image.

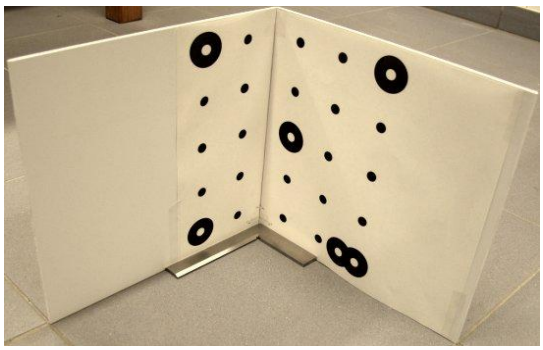

Figure 4: Background

1.4 System Design and Object Scanning

In the process of scanning, the user generally sweeps the laser plane over the object multiple times manually. However, since it is difficult to move the laser properly, some data occlusions can occur at the final data. For this reason a control tool developed for this process. The control mechanism consists of a stepper motor, electronic equipment to control the motor and transmission system to reduce the rotation speed.

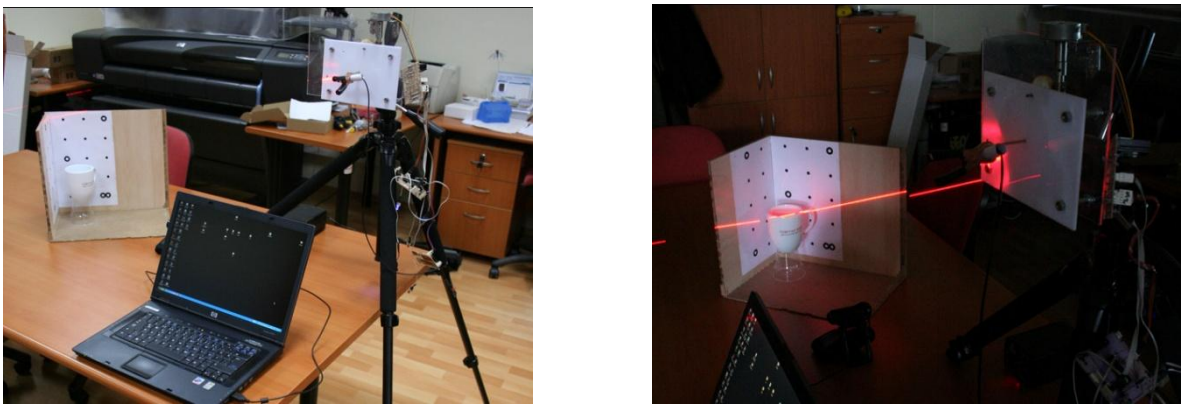

Figure 5: The System

1.5 Scanned Objects

After formation of the system, different types of objects in term material were scanned both manually **Fig (6)** and automatically **Fig (7, 8)**.

Figure 6: Automatically scanning

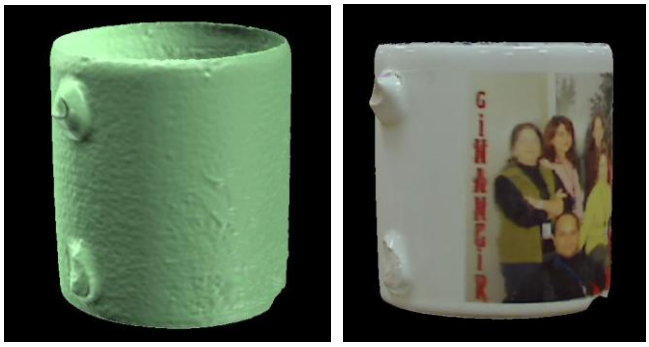

Figure 7: Manual scanning

Figure 8: Automatically scanning

2. RESULTS AND RECOMMENDATIONS

The system created in this study is a low-cost home-made laser scanner. By using this system, it is possible to get effective 3D models of especially small scale objects. The software provided by DAVID Laser Scanner allows making texture mapping with real texture data. Thus it is possible to create detailed virtual reality models. There are some matters to be taken into consideration in order to be able to get accurate and efficient results while scanning with this kind of system. The most important one of these matters is the location of the camera and laser source. There should be an appropriate base between camera and laser source and triangle angles should not be narrow. Another important factor is thickness of the laser line. It was observed that the thinner and well-focused laser line provides better results. On the other hand, if the light quantity that coming to the camera sensor is adjusted from the video settings of the software, then final data includes less noise.

3. REFERENCES

[1] http://www.david-lazerscanner.com/

[2] Zagorchev, L., Goshtasby, A.: A paintbrush lazer range scanner. Computer Vision and Image Understanding 101 (2006)

[3] Winkelbach, S., Molkenstruck, S., and M. Wahl,F., Low-Cost Lazer Range Scanner andFast Surface Registration Approach, DAGM 2006, LNCS 4174, pp. 718–728, 2006, Springer Berlin Heidelberg 2006

[4] Tsai, R.Y.: An efficient and accurate camera calibration technique for 3d machine vision. In: IEEE Conf. Computer Vision and Pattern Recognition. (1986) 364–374