OPTOMOTIVE

OPTOMOTIVE MEHATRONIKA, D.O.O.
V MURGLAH 229, SI -1000 LJUBLJANA
T: +386 1 429 29 14
M: +386 31 345 993

INFO@OPTOMOTIVE.SI
WWW.OPTOMOTIVE.SI

3D Rotational Laser Profilometer developed by OptoMotive in cooperation with the Faculty of Mechanical Engineering of Ljubljana

Three-dimensional scanning of objects of cultural heritage with a rotational laser Profilometer (3D Scanning of Large Statues)

Abstract

The paper describes development and the use of the rotational laser profilometer, which bases on the principle of laser triangulation. By using two laser projectors, we gain possibility of measuring of close (macro) and distant (tele) objects. The measuring system uses a digital high-speed FPGA based camera Cameleon with built-in programmable image processor, which essentially saves the computer processing power and communication bandwidth. Calibration is based on a measurement of the reference surface. Measuring system was developed to measure large objects, like objects of cultural heritage. The paper presents an example of measuring the statue of the Mercury, whose natural size is 3.5 x 2 x 1.5 m. It was measured from 300 different views. The achieved overall precision was 1.2 mm.

About 3D scanner

A 3D scanner is a device that analyzes a real-world object or environment to collect data on its shape and possibly its appearance (i.e. color). The collected data can then be used to construct digital, three dimensional models. Many different technologies can be used to build these 3D scanning devices; each technology comes with its own limitations, advantages and costs.

Functionality of the 3D scanner

The purpose of a 3D scanner is usually to create a point cloud of geometric samples on the surface of the subject. These points can then be used to extrapolate the shape of the subject (a process called reconstruction). If color information is collected at each point, then the colors on the surface of the subject can also be determined.

3D scanners are very analogous to cameras. Like cameras, they have a cone-like field of view, and like cameras, they can only collect information about surfaces that are not obscured. While a camera collects color information about surfaces within its field of view, a 3D scanner collects distance information about surfaces within its field of view. The "picture" produced by a 3D scanner describes the distance to a surface at each point in the picture. This allows the three dimensional position of each point in the picture to be identified.

For most situations, a single scan will not produce a complete model of the subject. Multiple scans, even hundreds, from many different directions are usually required to obtain information about all sides of the subject. These scans have to be brought in a common reference system, a process that is usually called *alignment* or *registration*, and then merged to create a complete model. This whole process, going from the single range map to the whole model, is usually known as the 3D scanning pipeline.

OPTOMOTIVE MEHATRONIKA, D.O.O.
V MURGLAH 229, SI -1000 LJUBLJANA
T: +386 1 429 29 14
M: +386 31 345 993

INFO@OPTOMOTIVE.SI
WWW.OPTOMOTIVE.SI

Technology

The triangulation 3D laser scanners are also active scanner that use laser light to probe the environment. With respect to time-of-flight 3D laser scanner the triangulation laser shines a laser on the subject and exploits a camera to look for the location of the laser dot. Depending on how far away the laser strikes a surface, the laser dot appears at different places in the camera's field of view. This technique is called triangulation because the laser dot, the camera and the laser emitter form a triangle.

Laser triangulation

Rapid laser triangulation is one of the methods for 3D object surface geometry acquisition. It is based on illumination of the object surface with structured laser light (Figure 1). The illuminated surface is acquired with a camera. The acquired image is usually processed by a PC to obtain a 3D profile.

Standard digital cameras are usually used for optical triangulation nowadays. Such a camera is connected to a PC over the bus (USB or FireWire), so that PC obtains a 3D shape of the object surface. In order to measure more than one profile (i.e. the whole surface) we usually move the projector or the measured object during multiple profile acquisition, and that way we can measure the 3D coordinates of the object surface. The bus is a bottleneck for higher measurement speed. When simultaneously processing images from multiple cameras the image processing speed becomes also a bottleneck. The Cameleon camera solves these problems by employing integrated image processing. The Cameleon enables faster creation of 3D models of complex models (human body for example) and thus essentially saves the computer processing power.

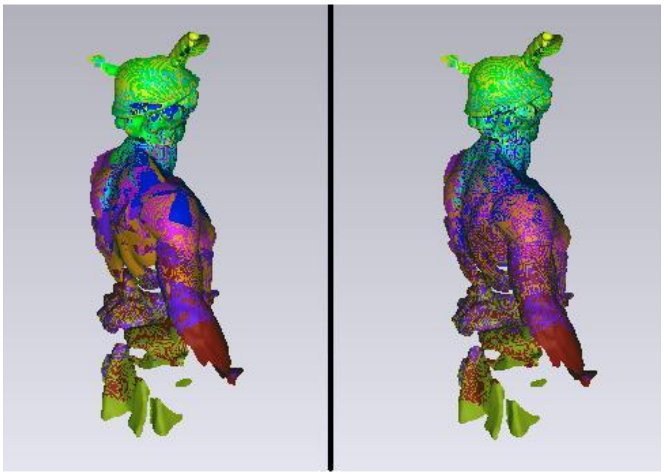

Figure 1: an example of image acquisition (left and right side of the model

OPTOMOTIVE

OPTOMOTIVE MEHATRONIKA, D.O.O.
V MURGLAH 229, SI -1000 LJUBLJANA
T: +386 1 429 29 14
M: +386 31 345 993

INFO@OPTOMOTIVE.SI
WWW.OPTOMOTIVE.SI

3D Rotational Laser Profilometer

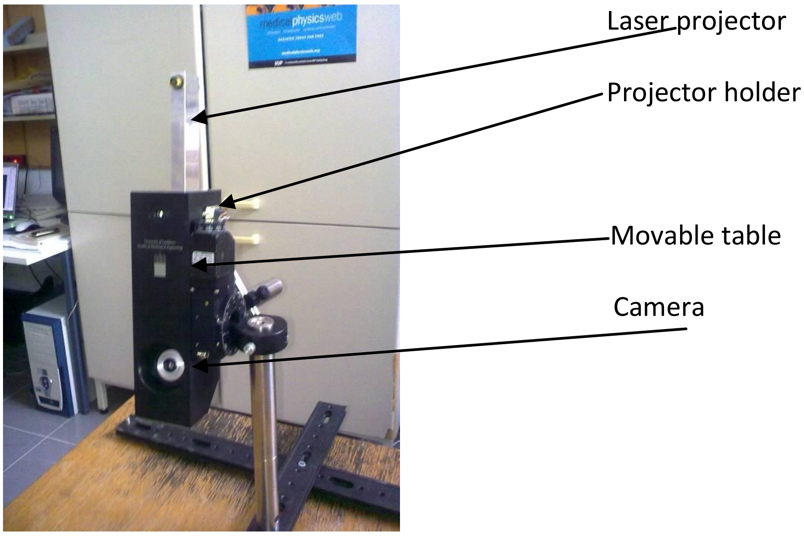

Figure 2: 3D Rotational Laser Profilometer

We have developed 3D Rotational Laser Profilometer for object surface geometry acquisition, which is based on the commercial version of the OptoMotive´s FPGA camera family Cameleon. It is built with Aptina monochrome sensor MT9V034, with resolution 752x480 pixels and is able to acquire 64 full frames per second. The FPGA do an image processing and send the profiles only to the PC.

OPTOMOTIVE

OPTOMOTIVE MEHATRONIKA, D.O.O.
V MURGLAH 229, SI -1000 LJUBLJANA
T: +386 1 429 29 14
M: +386 31 345 993

INFO@OPTOMOTIVE.SI
WWW.OPTOMOTIVE.SI

Summary

We have measured and created a 3D shape of the Mercury Statue (Figure 3), located in Ljubljana. The results were precise and satisfied our expectations.

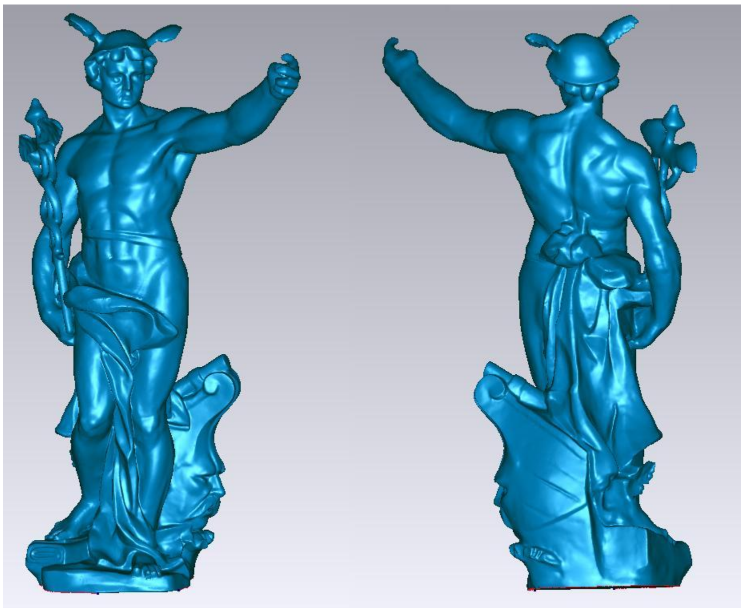

Figure 3: The 3D model of the Mercury Statue

Beside the use of our cameras in above described purpose, the achieved results give us an opportunity to use cameras in any application when the 3D shape of object is needed to obtain.

Contact data:
OptoMotive, mechatronics Ltd.
Phone/Fax: +386 1 429 29 14
Email: info@optomotive.si
Web: www.optomotive.com

Ljubljana, October 2011