Application Example: Reverse Engineering

Art and Archaeology: 3D optical digitalisation of the sculptures on the Charles Bridge

Measuring Systems: ATOS, TRITOP
Keywords: Restoration, archiving, outside measurement

The sculpture of Saint Vojtech was the first sculpture to be digitized. The research on the original and its copy can derive information about the actual condition of the sculpture and the damaging influence of various environment factors. Also the accurate digitizing data can easily be archived, compared and used for making a replica.

GOM mbH
Mittelweg 7-8
38106 Braunschweig
Germany
Phone +49 531 390 29 0
Fax +49 531 390 29 15
info@gom.com

GOM International AG
Bremgarterstrasse 89B
8967 Widen
Switzerland
Phone +41 5 66 31 04 04
Fax +41 5 66 31 04 07
international@gom.com

GOM France SAS
10 Quai de la Borde - Bât A2
91130 Ris Orangis
France
Phone +33 1 60 47 90 50
Fax +33 1 69 06 63 60
info-france@gom.com

GOM UK Ltd
Business Innovation Centre
Coventry, CV3 2TX
Great Britain
Phone +44 2476 430 230
Fax +44 2476 430 001
info-uk@gom.com

GOM Branch Benelux
Interleuvenlaan 15 E
3001 Leuven
Belgium
Phone +32 16 408 034
Fax +32 16 408 734
info-benelux@gom.com

Reverse Engineering / Art and Archaeology

3D optical digitalisation of the sculptures on the Charles Bridge

Measuring Systems: ATOS, TRITOP
Keywords: Restoration, archiving, outside measurement

In 1999 the State institute for the Care of Historical Monuments in Prague with the support of the Czech Ministry of Culture began a long-term project, monitoring the Charles Bridge sculptures. The Charles Bridge, dating from the 14th century, is not only a significant historical monument, but also a gallery of baroque plastics.

The sculptures and sculpture groups are affected by degradation and the original plastics were therefore gradually replaced by copies. The research on the originals and its copies can derive now information about the actual condition of the sculptures and the damaging influence of various environment factors. For the monitoring of the actual situation, non-destructive measuring methods, including a detailed photo documentation was used. To actually get the 3D form, the "flat pictures" can not give enough information. Therefore an accurate digitizing was needed, producing data which can easily be archived, compared and used for making a replica if needed.

The sculpture of Saint Vojtech was the first element to be digitized. The original, made from sandstone by the most famous sculptor Ferdinand Maxmilian Brokoff, is dated from the 18th century and is 6 m high.

The digitizing was made by MCAE Systems s.r.o. using the optical measuring systems TRITOP and ATOS from GOM.

TRITOP is a photogrammetry system which measures the exact position of markers. The system is portable and consists of a high resolution digital camera, a scale bar and some coded markers and a notebook with the evaluation software. The markers are placed on the object and some coded markers and one or two scale bars are added. Then images are taken with the digital camera from different positions. These images are downloaded into the notebook and then the evaluation software defines the exact 3D position of the center of the markers on the object.

The optical digitizer ATOS is portable and works on the principle of projecting light fringes on the object. Each projected image is viewed by the two CCD cameras built in the ATOS sensor. Then, from the images, a cloud of points, which exactly defines the surface shape of the measured object is calculated. Depending on the resolution of the CCD cameras in the ATOS digitizer, 400 000 up to 1,3 mil object points are captured and measured in one measurement. The clouds of points are then registered into the predefined grid of marker points defined by TRITOP. From all the measurements a complete information about the whole surface of the measured object is captured. To get good details, and allow an efficient working, the ATOS digitizer can be calibrated to a measuring area of 100 by 80 mm and then, to scan large areas to 350 by 280 mm or bigger.

Fig. 1: Application of the markers on the monument

Combining both systems (TRITOP and ATOS) assures excellent accuracy and easy integration of the individual digitizing measurement, therefore both systems are used to scan this sculpture. To be able to handle the big amount of data, the measurement had to be split into the front part, the back part and the pedestal, but all data is in the correct coordinate system.

The sculpture was first cleaned and then the reference markers are applied, partially using a lift with the cabin as shown in fig. 1. Totally about 1600 marker points were placed on the sculpture (fig. 2).

Then TRITOP is used to exactly define the position of all these markers. Typically 100 views were taken during the day using the digital camera. From all these pictures, the position of the markers in the images are defined. Then the images are virtually matched together to define the actual camera position during recording and then calculated the exact 3D position of all markers as given in fig. 3. The marker "grid" is then used to integrate the ATOS scanning measurements automatically into their position.

Fig. 2: detailed view of the statue with the markers

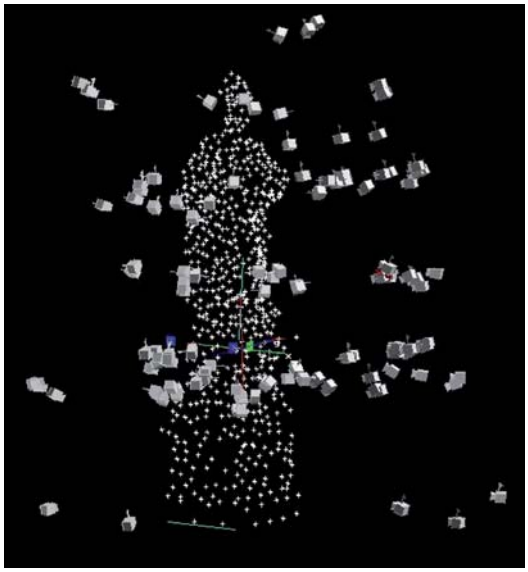

Fig. 3: Marker and reconstructed camera positions

The digitizing by the ATOS system was done mainly during the night, to have low ambient light conditions and good fringe contrast on the sculpture. For the digitizing, the ATOS sensor was mounted on a camera crane. This crane was controlled by a joystick and had a camera built in to verify the working area. Then the ATOS sensor was positioned in working distance around the sculpture and measurements were taken as given in fig. 4.

For this sculpture, more than 350 views are digitized by the ATOS digitizer and more than 37 million data points are gathered. Depending on the sculpture and the data density needed, the measurement of one sculpture takes typically 2 to 3 days for an experienced team.

Fig. 4: Set up to digitize the sculpture

From all the measurements taken by the digitizing system, a digital 3D model was established as given in the enclosed figures.

Beside all care which was taken, some small and hidden areas are inaccessible for optical triangulation measurement. These areas can be modeled by Reverse Engineering to get a complete digital reconstruction of the actual sculpture. Using optical digitizing of this quality on a sculpture on a bridge is very significant and shows the potential of this techniques for flexible and detailed digitizing needs. This job is a challenge for the equipment and the operators. This fine sculpture was made by a leading artists with highly detailed features and hidden areas, asking for the best crew with an adequate equipment. Now the job is done, and the data is saved on CDs. It will help to secure and protect the sculptures of the Charles Bridge hopefully long into the next century.

Fig. 5: Flat shaded view of the scanner data as given by ATOS of the statue.

Fig 6: Flat shaded view of the scanner data as given by ATOS of the pedestal.

We would like to thank the State institute for the Care of Historical Monuments in Prague and the operators of the equipment for their trust in our equipment and the dedication to this job.

Additional information on Charles Bridge, Prague can be found on http://www.prague-spot.com/charles-bridge.