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DEMONSTRATION OF CANADIAN 3D TECHNOLOGY FOR HERITAGE RECORDING IN CHINA

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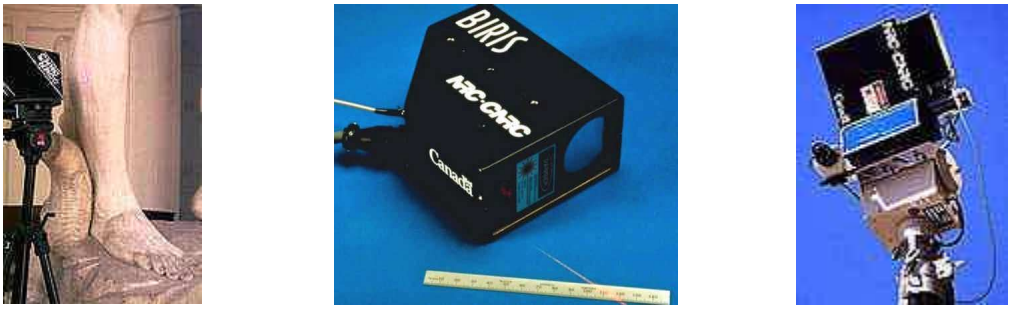
ABSTRACT

In 1999, a laboratory prototype Biris 3D Laser Scanner system developed at the National Research Council of Canada (NRC) was used in a pilot project to demonstrate the heritage recording applications of 3D imaging technology in China. During the project, several logistical and technical challenges developed which initially threatened the success of the project. In the end, these challenges strengthened the outcome in terms of equipment design as well as applications to other heritage sites in China. The purpose of this paper is to present a summary of the work undertaken during the pilot project, including the technical challenges encountered as well as on plans for continued application of the 3D imaging in China.

INTRODUCTION

As discussed in our paper *Heritage Applications of NRC 3D Imaging Technology* during the first Canada-Italy Workshop in Ottawa in 1999, three high-resolution 3D imaging systems developed at NRC have been applied to a variety of heritage recording projects (1). The three systems, the ***High Resolution Laser Scanner***, the ***Biris 3D Laser Camera*** and, the ***Large Field of View Laser Scanner***, have been designed for different imaging applications. The High Resolution Laser Scanner (Figure 1a), simultaneously digitizes the 3D shape and color of traditional museum objects and provides maximum depth resolution of 10 microns (2-4). The Biris system (Figure 1b) is a portable 3D monochrome imaging system and is ideally suited for field recording applications (5). It provides an accuracy of 80 microns at a range of 0.3m. The Large Field of View system (Figure 1c) is under development for high-resolution monochrome 3D digitization of large structures at a standoff distance from 50 cm to 10 m (6). At a standoff of 50 cm, it provides a resolution of 70 microns.

These systems use a low power non-damaging laser light to digitize sequential overlapping images from multiple points of view over the surface of an object or site. Once scanned, data modeling and display software is used to integrate the multiple view data sets into a seamless archival quality high-resolution 3D digital model of the object (7).



(a) (b) (c)

Figure 1. The High Resolution Laser Scanner (a), shown imaging the right leg of Michelangelo's *David*, can be mounted on a tripod for high resolution monochrome imaging of details such as tool marks. The Biris 3D Laser Camera (b) can be mounted on either a conventional tripod or on a linear translation stage for scanning. The Large Field of View Laser Scanner (c) can be mounted on a telescoping tripod and raised to a height of 10 m to scan large objects such as outdoor sculpture.

In addition to several heritage recording demonstration projects undertaken with partners in Italy, a number of other projects have also been undertaken with international partners in the USA, the United Kingdom, France and Israel.

As a result of the construction of a hydroelectric dam on the Yangtze River, in the Three Gorges area of China, an estimated 800-1000 heritage sites in will be flooded and lost by 2009. The recording of these sites represents a significant challenge for Chinese heritage officials. In September, 1999, The Canadian Foundation for the Preservation of Chinese Cultural and Historical Treasures in collaboration with the State Administration of Cultural Heritage (SACH) organized a pilot project to demonstrate the application of Biris 3D technology for recording some of these sites.

The project was undertaken by to one of our industrial partners, Innovision Géomatique Inc., (www.innovision.qc.ca/). Innovision is a professional geomatics company and is licensed by NRC to provide a commercial service based on the Biris 3D imaging technology. In 1998 and 1999, Innovision won the Center for Topographic Information's National Topographic Database Award of Excellence.

During the project, several logistical and technical challenges developed which initially threatened the success of the project. In the end, however, these challenges strengthened the outcome in terms of equipment design as well as applications to other heritage sites in China.

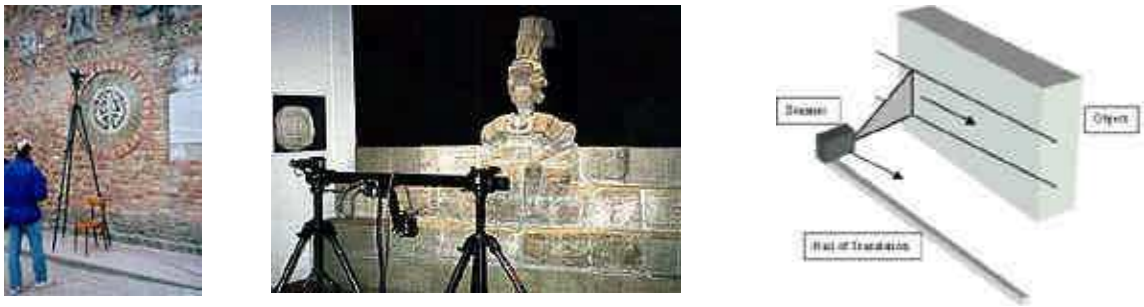
THE BIRIS 3D LASER CAMERA SYSTEM

For the project, NRC loaned our laboratory prototype Biris system to Innovision. The Biris Camera is a portable digital 3D monochrome imaging system and is ideally suited for field recording applications, where a record of the three-dimensional shape of an object or feature is required (8). The camera can be mounted either on a conventional tripod, (Figure 2a) or on a linear translation stage between two tripods (Figure 2b). It has a maximum

range of 2 m and an accuracy of 80 microns at a range of 0.3 m and 1.8 mm at 1 m. Most important for field work, it can also be operated using a portable generator. A laptop computer is used to control the scanner while a dual processor Pentium III computer with 512MB of RAM is used to process the image data. The software includes Windows 95 (controller), Windows NT for the processing computer, PolyWorks 3D model creation software as well as image translator and system calibration software.

To record an entire object, sequential overlapping images are recorded from multiple viewpoints. This is accomplished by repositioning the camera along the face of the object at the calibrated standoff distance (Figure 2c). Once the entire object has been, scanned, the data recorded from the multiple views is merged or integrated into a seamless archival quality high resolution 3D digital model of the object using PolyWorks software from Innovmetric Software Inc (www.innovmetric.com).

This system has been used to digitize architectural building elements and sculptures in Italy. Innovision has also used it to digitize a section of a Hieroglyphic Stairway at the Peabody Museum at Harvard. Shape Grabber Inc., manufactures the camera as the ShapeGrabber™ (www.shapegrabber.com).



(a) (b) (c)

Figure 2. The Biris 3D Laser Camera is a compact and portable monochrome imaging system and is ideally suited for field recording applications. In (a) the camera is shown attached to a motorized rotation stage mounted on tripod at the Abbey of Pomposa near Ferrara. In (b) the camera is shown mounted on a linear translation stage scanning a section of the Hieroglyphic Stairway in the Peabody Museum at Harvard. Moving along the motorized translation stage, the camera scans sections of the object at a calibrated standoff distance as shown in (c). The sections are then merged to form a complete 3D digital model of the object.

FIELD WORK IN CHINA

Linjiangyan Buddhist Statues

The initial site selected by the Chinese officials for scanning was the Linjiangyan Buddhist Statues (Cliff Side Buddhist Statues) (Figure 3), in Zhongxian about midway between Chongqing and Wanxian on the Yangtzee River. The Statues are the earliest Tang Dynasty Buddha engravings found in the eastern part of Sichuan and, along with the city, will be flooded by 2009.

From Beijing, the Innovision team together with representatives of the Canadian Foundation, SACH officials and I flew to Chongqing. Shortly after our arrival in Chongqing, we learned of our first serious logistical problem. The generator and one of the

tripods, which Innovision had shipped from Canada, had been left in Beijing. As arrangements had been made to ship the equipment the next day by truck over the mountains to Zhongxian, it would not be possible to have sent to Chongqing in time for the trip. Instead, we would have to rely on the local electricity.

While the equipment was enroute by truck, the team boarded a hydrofoil in Chongqing for the four-hour trip down the Yangtze River to Zhongxian.

Our first impression was that the site was ideal for scanning using the Biris system. It is carved in five niches in a stone wall covering an area about 5 meters wide by 2.5 meters wide. If all went well, it would be possible to set the equipment up and scan the site in a day. This would enable Innovision to provide an archival quality 3D record of the site - which will be lost forever - to the Chinese heritage officials.

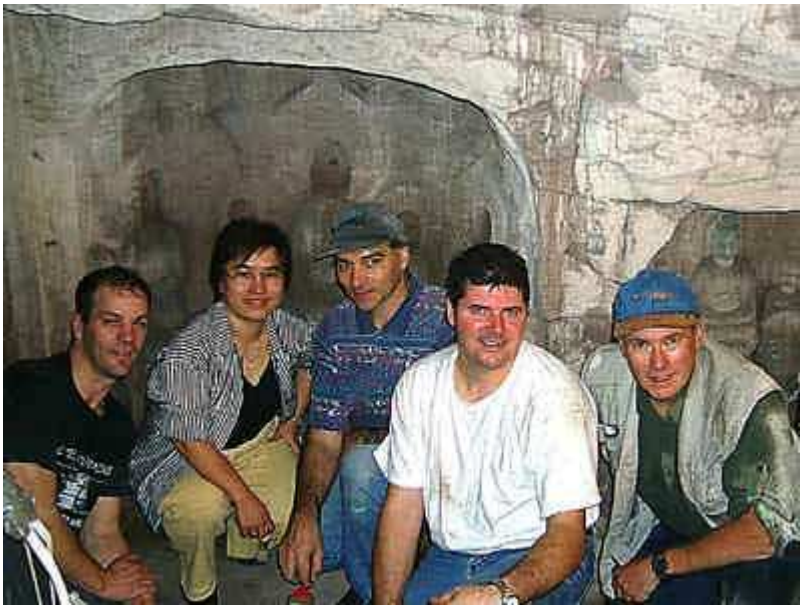


Figure 3. The Canadian team at the Linjiangyan Buddhist Statues (Cliff Side Buddhist Statues) in Zhongxian. Although the site was ideal for scanning using the Biris system, electrical problems prevented the use of the system. From left to right, Denis Mercier, Dr. Nelly Ng, Guy Côté, Serge Chabot and John Taylor

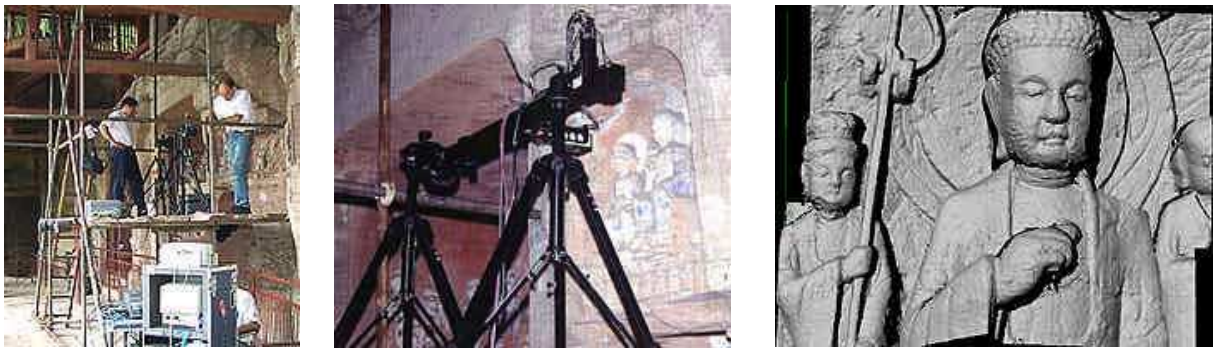
This impression, however, soon started to fade. Shortly after the system was set up, the electrical power went off – not only at the site, but also throughout Zhongxian. It had been shut down for maintenance and would not be turned on again until later that evening. Although the Chinese officials located a generator, unfortunately we lacked the necessary plugs and adapters to connect it to our equipment. After making several attempts to modify the generator's connections, we concluded that we could not use it to operate the Biris system.

When the power came back on, we set the system up and again tried to scan the site. However, the power was insufficiently stable to operate the system. After making several attempts and trying various options, we concluded that we would be unable to scan the site.

Although this was most discouraging for the Canadian team, far from indicating any discouragement, the SACH officials advised they had made plans to move the team to a new site – the important Bei Shan (Big Foot) rock-carving site near Dazu. The electrical supply was considered to be more stable in the area. This meant returning to Chongqing and driving 100-km west to Dazu.

Bei Shan

The Bei Shan site dates to the ninth century and consists of rock carvings cut into 264 niches on a large hillside rock outcrop. Since Dazu is not in the Three Gorges area, this site is not threatened by inundation. It has become a popular cultural tourism site – attracting approximately 400,000 visitors annually. To accommodate the visitors, new roads and facilities are being constructed into the area. A substantial site conservation program has also been established. To protect the rock face from erosion by water as well as vandalism, a well designed enclosure with a roof and drainage system has been constructed along the entire site.



(a) (b) (c)

Figure 4. The Biris system set up on scaffolding at niche#147 at Bei Shan (a and b). The 3D model data (c) data was used to demonstrate the application for monitoring of erosion to the Bei Shan officials.

Despite this, typical of many similar sites also around the world, erosion of the surface of the carvings – due to spalling or flaking of fragments of the rock surface - remains a major problem. The SACH officials advised that in addition to using the 3D technology for archival recording of sites in the Three Gorges area, they were also interested in applying it for conservation applications in monitoring erosion of sites such as those at Bei Shan.

The Biris system was set up on scaffolding at niche #147 at Bei Shan (Figure 4a & b). Despite some further technical problems, which were again related to the stability of the electrical supply, Innovision successfully scanned high quality image data from the central section of the niche. This data was then merged to prepare a digital model (Figure 4c) which was used to demonstrate the application for monitoring of erosion to the Bei Shan officials.

CONCLUSIONS

Earlier, I mentioned that the technical challenges experienced actually strengthened the outcome of the project.

The problems led to the opportunity to scan the site at Dazu and to demonstrate the technology for a different, yet significant heritage recording application problem. This significantly broadens the potential application of the technology in China beyond the immediate need in the Three Gorges area. When the Innovision team returned to Beijing, SACH officials advised that they wanted to apply the technology for both applications. Plans are currently being made by the Canadian Foundation and Innovision to design and develop a practical field system for SACH as well as to train technicians in its operation.

The technical problems encountered will also enable Innovision to design and build a much more portable and robust system (including a generator) for SACH, than they likely would have, had the problems not been experienced.

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