

EVALUATION OF SHAPECAPTURE AS A HERITAGE DOCUMENTATION AND MONITORING TOOL.

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ABSTRACT

Increasingly, more tools are available for the documentation of heritage assets. Significant time is often required to evaluate a particular tool for such factors as precision, efficiency, cost and possible cost savings in the context of project delivery. This presentation will examine these questions in the case of Shapecapture. Shapecapture is a photogrammetric software package that uses digital non-metric images for documentation and monitoring applications. The software is capable of producing 3D coordinates, 3D models with texture mapping, camera calibration data from a single image, automatic target extraction, stereo matching of selected points and pixel matching. The presentation will focus primarily on the production of 3D coordinates, automatic target extraction and stereo matching, using three case studies to illustrate the respective outcomes of each scenario when used for recording and monitoring applications.

1.0 HERITAGE RECORDING OF FORT HENRY NATIONAL HISTORIC SITE OF CANADA.

1.1 Recording Needs

The Heritage Conservation Directorate Directorate (HCD) of Public Works and Government Services Canada (PWGSC) has been recording the Fort Henry site for the past several years. The structures on this site vary from large flat masonry walls to more complex towers that have multiple curved surfaces. Because of the variations of the geometries of these assets, a range of tools has been used in their documentation. These tools range from rectified photography, photogrammetry and direct survey by means of a total station. Traditionally, the area in question, a curved masonry wall joining two flat walls, would have been documented by photogrammetry or by direct survey. In this case, it was decided to evaluate the Shapecapture software as a tool to capture the desired data. For this area of the fort, all mortar joints had to be documented.

1.2 Evaluated Solution

A photogrammetric pair of the curved area was captured using a digital SLR camera with a 20mm lens. The camera and lens configuration was calibrated with the Shapecapture software prior to the registration of the model. Each mortar joint had to



Figure 1. Fort Henry National Historic Site of Canada.

be drawn to produce line elevations. When using a total station to do similar work on site, the top of each mortar joint is surveyed and then drawn by connecting the points horizontally and having a vertical line automatically inserted at each survey point. The vertical lines are then trimmed or extended to complete the drawing. The use of Shapecapture would involve picking the common points of the top of each joint in each photo. This would probably be difficult and tedious and could

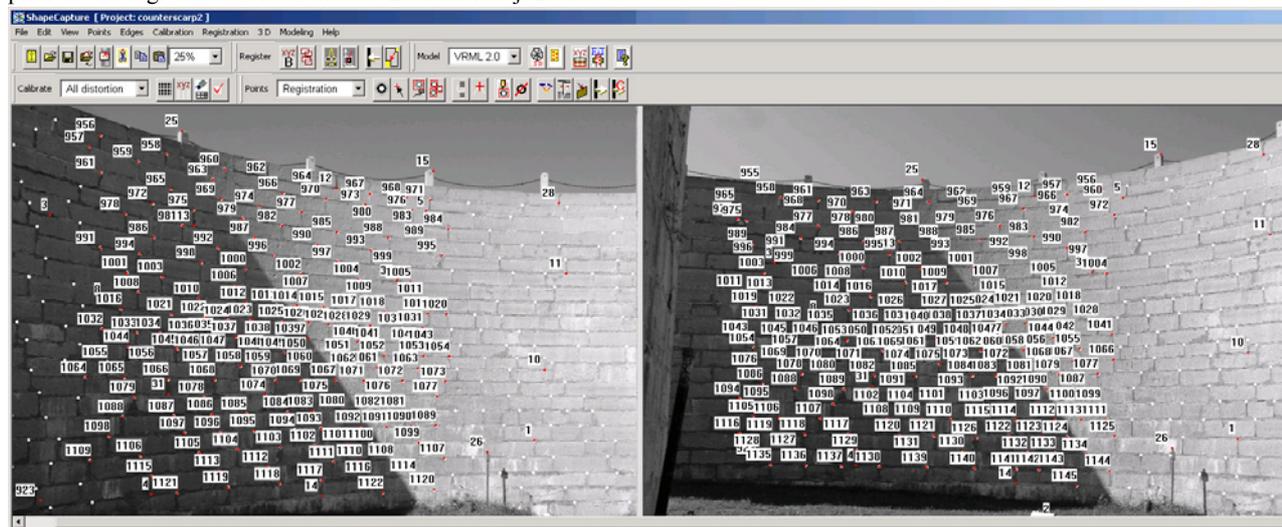


Figure 2. points to stereomatch

result in the mismatching of common points. Therefore, the target recognition tool within Shapecapture would be evaluated to choose a large amount of points automatically. However, this would involve the use of targets on the top of each joint, an unreasonable way of identifying the points since this would not be efficient. The solution was to capture the photographs and add targets with the use of Photoshop. The top of each joint was identified with a white circle on each photo. These images were then imported into Shapecapture and after registering the model, the points were identified in the two photos with the target recognition tool. Local coordinate system points were used for the registration of the model to ensure that the resulting model would be in the same common coordinate system, facilitating the drawing compilation. Since the mortar joints were identified with a consistent target, the characteristics of the target was imputed into Shapecapture to ensure proper target recognition. This resulted in both photos now having all the joints identified, but with random numbering, that is, a specific joint is not numbered with a common number in the pair. Therefore the model could not be accurately calculated in a XYZ coordinate list. The stereomatching tool within Shapecapture was evaluated to accurately match these points.

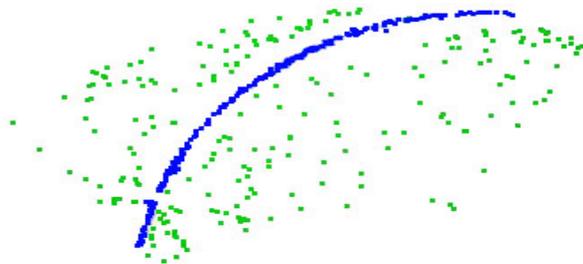


Figure 3. Top view of resulting stereomatched points (blue points showing successful match)

1.3 Results

The model was recalculated several times with refinements for each calculation to improve the percentage of properly matched points. It is estimated that points were positively matched at a rate of 75-80%. The 20-25% of points that were not matched could have been manually matched, however this would prove less efficient than other methods, therefore, the missing areas were manually surveyed with a total station. This still proved to be a good exercise, and could be appropriate when encountering a similar situation that was not anticipated and that was thought not to require survey equipment. With a digital camera, a photogrammetric pair of the particular area could be captured to help complete accurate drawings. This would prove useful for remote sites that may result in significant costs to send a survey team.

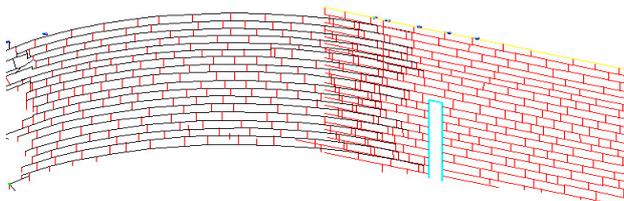


Figure 4. Curved area drawn from Shapecapture data and survey.

2.0 MONITORING OF THE MOTHERWELL HOMESTEAD BARN NATIONAL HISTORIC SITE OF CANADA.

2.1 Monitoring Needs

The barn at the Motherwell National Historic Site of Canada has been experiencing structural movements for the past several decades. Settlement of the stone foundation has led to the failure of some structural members of the wood framing. In 2004 HCD completed a condition assessment of the barn and recommended that the structure be monitored to better quantify the rate and location of settlement movements prior to undertaking efforts to stabilize the structure.

2.2 Evaluated Solution

A major challenge for this project was the client's limited budget, making it difficult to send a survey crew at the desired monitoring time interval. In 2005 a decision was made to produce an initial survey as a base for future comparisons. In order to achieve the desired measurement time interval of once a year, Shapecapture would be used to evaluate/capture overall movements. In lieu of a survey crew, a digital SLR camera was sent to the site (2,600 km from HCD's office in Ottawa) so that site personnel could take photographs at pre-determined stations. The camera and photographs were then returned to HCD's office for a comprehensive evaluation and comparison with previous models.



Figure 4. Site staff taking photos at Motherwell Homestead NHSC

This exercise was to evaluate the Shapecapture software in this application. Some of the questions to be answered were: could a camera be sent to the site for staff to take the photos, and what accuracy could be achieved? The deltas of each point would be produced to gauge the movements of the barn. It was determined that a precision of 50mm or less would be good. Any greater movement could raise the possibility of sending a survey crew to measure the barn at a greater precision. An opportunity to assess the software presented itself in the summer of 2006. The structural engineer had planned to raise the timber structure of the barn in certain areas by inserting shims between the stone walls of the foundation of the structure and the timber portion. A series of photos were captured before and after the shimming. The documentation team then registered and compared the two models to determine the amount of shimming done. This amount was not known to the documentation team, and was to be communicated to the engineer who provided guidance during the shimming exercise and knew of the amount of displacement. The results were

communicated, the amount of movement detected by examining the data was of 50mm, essentially the amount of actual shimming. The vertical measurements seem to have a precision of 25mm when points are measured from 3 photos/stations. The X and Y precision is in the order of 30mm when using a minimum of 3 stations and 50mm+ when using 2 stations and depending on the geometry of the two stations.

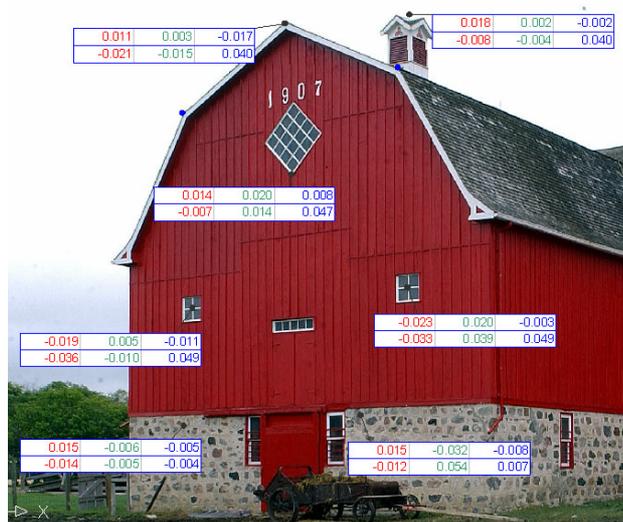


Figure 5. RGB-XYZ data comparing deltas of 3 epochs.

2.3 Results

So far, the precision of the data seem to be adequate. The measurement of the shimming was also very positive. One challenge remaining was the levelling of the models. To this point, each model was transformed using common points to compare them. The risk in this method was not knowing if the matched points had moved or not. Levelling the cameras on site was attempted, but this system did not replace the levelling of a total station. As a result, we could not measure settling of the foundation, measurements that were desired by the engineer.

The monitoring project will continue to evolve to improve the method. Solutions being considered are the installation of vertical benchmarks around the barn that would be visible when taking the photos, or training the site staff on the use of a level to measure the building corners.

As a result of this monitoring program, other applications are being considered. One application that will move forward is the monitoring of a floor of a building sitting on permafrost in a remote part of northern Canada. This program will be a continuous monitoring program in that several cameras will be permanently installed and will take photo's at set intervals. Targets will be placed on the floor in order to use the target recognition option to increase the efficiency of the processing.

3.0 MONITORING OF THE WEST BLOCK MACKENZIE TOWER, PARLIAMENT BUILDINGS OF CANADA.

3.1 Monitoring Needs

The Mackenzie Tower is a significant feature of the West Block, one of the four buildings comprising Canada's Parliament Buildings. The tower has recently shown evidence of erosion of certain sandstone panels. The primary intent of the monitoring program has been to evaluate photographs taken at a three month intervals since 2005. Quantifying the rate of erosion is an ongoing challenge. Laser scanning was eliminated as an option because of the absence of a stable platform for each area to measure. The use of a crane would also not provide an adequate platform.

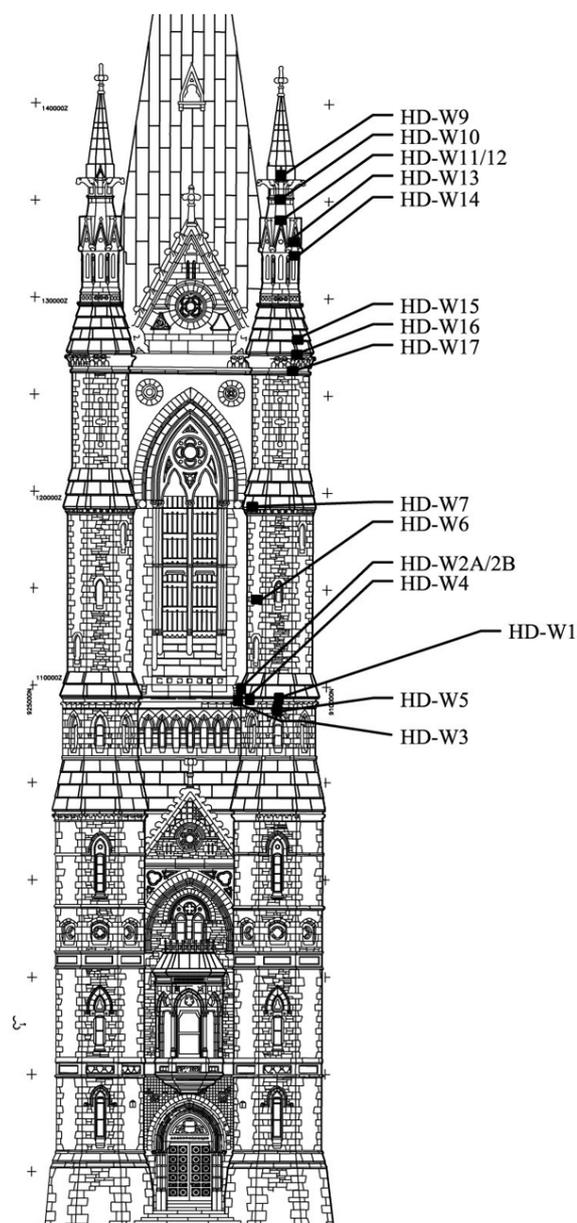


Figure 6. Monitored panels.

3.2 Evaluated Solution

It was decided to evaluate Shapecapture as a tool for generating point cloud data for panels that are suspected of experiencing rapid rates of erosion. These photographs would be captured at a distance of approximately one metre in predetermined areas.

A photogrammetric pair using a digital SLR was captured of each panel from a crane. Some photogrammetric pairs were registered and sent to a consultant for assessment. This consultant has developed a method that matches pixels within the stereopair. This method is proving to work well on surfaces that have textured surfaces such as the sandstone on the Mackenzie Tower. The resulting point cloud approximates the density of data produced by a close range laser scanner. The intent is to compare the various scans of a specific panel and measure the differences in millimetres, and possibly microns, of the eroded areas. A benefit to this method is that it is quite similar to a traditional photogrammetric project in that these digital photos can be evaluated at a future date and for very specific areas.



Figure 7. SLR Cameras to capture stereopair.

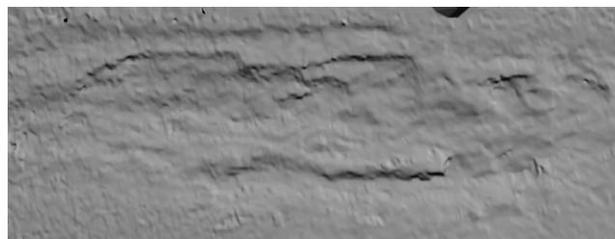
Another benefit of this method was that there was little initial cost to take the photogrammetric pairs. These pairs were photographed at the same time as the visual record photos. Once the pairs were photographed, the team could then decide which panels to evaluate. Another similar advantage is that at the start of any monitoring program, it may be difficult to determine where the greatest movement/erosion occurs. This method allowed the team to capture many pairs or areas without sacrificing the project budget. This would allow many areas to be recorded for initial data to compare in the future. Once an area is deemed to have visual evidence of erosion, the initial pair could be evaluated against a later pair to quantify the amount of erosion.



Figure 8. Stereopair.

3.3 Results

This method is continuing to be evaluated. The consultant used for the stereomatching service has done some successful testing by comparing data of a laser scan to the stereomatching pair. The next phase of the project will be to compare the data of multiple visits to see if the precision of the stereomatching models is sufficient to detect erosion.



Model



Photo

Figure 9. Visual comparison of model and photo.

4.0 CONCLUSION

Even if some of the projects presented have had some challenges, there are definite future possibilities in monitoring and heritage recording using Shapecapture. Already, useful data is being produced for the barn monitoring which resulted in the design of an upcoming monitoring program. This method could have an impact on our national heritage recording programs. The stereomatching could supplement the national photogrammetric program by capturing smaller details such as stone carvings. Like photogrammetry, this system would involve minimal initial cost, and could be processed only on an as-needed basis.

If successful, these monitoring projects may change how the Heritage Conservation Directorate undertakes documentation, such as capturing architectural elements like stone carvings. This tool could eventually be incorporated into HCD recording programs as a means of capturing large amounts of accurate 3D coordinate information for architectural details to be reconstructed at a later date, similar to the HCD's existing photogrammetric database of overall buildings.



Figure 10. Carvings that could be modeled by stereomatching.