Photogrammetry

Scenario
The presence of photogrammetry in courses and programs across the University of Wyndham shows just how pervasive this technology has become. Students in investigative forensics, a specialty in Wyndham’s College of Criminal Justice, use photogrammetry to document crime scenes. In the field, students use handheld cameras to take photographs of crime scenes from various angles and later use photogrammetry software to convert those data into digital 3D images that capture extraordinary details that can help an investigation. The stored data also give investigators options for studying a crime scene from different perspectives long after it may have been cleaned up. Once each semester, students practice aerial photogrammetry, using drones to take images of a scene—a technique that has proven invaluable, for example, to capture rich details of an automobile accident on a busy highway or to collect photographic data that can be used to create a 3D model of a fire-damaged building.

Working under a contract for the Department of Defense, engineering students use photogrammetry to create detailed studies of roadside bombs. In experiments that include explosions set off under decommissioned military vehicles, they use scores of cameras to record both the explosion and its aftereffects. Studying detailed images made through photogrammetry yields ideas to help protect soldiers and make vehicles less vulnerable to IEDs.

At a prehistoric site in Scotland, Wyndham archeologists use photogrammetry to link striations in rocks found at the site to their place of origin more than a mile away, a finding that suggests early humans had moved huge boulders into a form of monument that had not previously been recognized. Elsewhere, Wyndham botanists are cataloging seed pods from trees around the world. They use photogrammetry in the field to create images that enable close study and comparison of the pods in campus labs. Budding architects use photogrammetry to study details of notable historic buildings. Photogrammetry helps marine biologists track changes in coral reefs. In the university’s film school, photogrammetry is creating new channels for creativity in video games and animation.

One unexpected benefit has been in the School of Professional and Continuing Studies. Adult professionals in fields where photogrammetry has become a common tool—including architecture, engineering, manufacturing, and geology—are flocking back to the school for advanced training. Licensed surveyors, for example, need regular continuing education in photogrammetry techniques to keep their credentials up to date.

1 What is it?
Photogrammetry is the process of using photographs of real-world objects to create digital 3D representations of those objects. The photographs that serve as the inputs for photogrammetry can be acquired from airborne cameras (on a plane or a drone, for instance) or from cameras on the ground, including cell phones or fixed cameras mounted on tripods or poles. The technique is useful for creating models that represent large-scale objects, such as archeological sites or buildings, down to small objects and artifacts such as seeds and arrowheads. Photogrammetry can aid investigation and interpretation by providing new perspectives and revealing subtle details. Advanced photogrammetry can also allow for very accurate measurement.

2 How does it work?
A typical photogrammetry workflow starts with collecting photographs of an object taken from as many positions as possible. Software uses data drawn from those photos to create “point clouds” that get denser until a 3D “mesh” is generated, which is the basis of the full 3D model. Simple photogrammetry can be done using photographs from cell phones and low-cost or free apps. Sophisticated photogrammetry uses high-end scanners or an array of cameras that take high-resolution photos from multiple positions. If desired, users can 3D-print a physical version of those data. Depending on software and hardware, users can have either a modicum of control over the process or very fine-grained control. Typically the process includes not just the processing of photographic data from which the desired output is produced but also the inclusion of information about how the images were captured and under what circumstances, details that are essential for reproduction and archiving.

3 Who’s doing it?
One of the most dramatic uses of photogrammetry is its utility in recreating important archeological sites that have been destroyed by time or human activity. As part of the Syrian Heritage Project, for example, archaeologists are using photogrammetry to guide restoration of the Temple of Bel in Palmyra, which was demolished by ISIS soldiers. Making history in a different way, photogrammetry was used in 2015 to map a square mile of Philadelphia as part of logistics planning for a visit to that city by Pope Francis. Photogrammetry’s value as an education tool is in evidence at Wellesley College, where students photo-
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graphed statuary from the college’s Davis Museum to render detailed 3D models they could then study. At Purdue University, civil engineering students use photogrammetry for automated mapping and to assess how manmade and natural forces change landscapes over time. At the University of Minnesota, where photogrammetry is used in disciplines ranging from art and archaeology to earth sciences and theater, researchers developed a simple photogrammetry rig for use in the field. A student at the University of Minnesota, Twin Cities used photogrammetry to capture details of spikes on a seed pod from a horse chestnut tree.

4 Why is it significant?

One benefit is that photogrammetry offers the capability for users to create models—either 3D digital representations or physical objects created with a 3D printer—that would otherwise be impossible or difficult to obtain, providing angles and perspectives that greatly enhance the study of objects, buildings, and landscapes. Photogrammetry also offers new capacities for precision in measurement. Those functions give photogrammetry significant value in applications across a wide range of fields of work, including engineering, construction, architecture, agriculture, manufacturing, and equipment design. Images produced via photogrammetry are appropriate for incorporation in virtual reality and augmented reality and can provide the building blocks for further digital manipulation in 3D design software, giving students the ability to remix physical objects in the virtual space.

5 What are the downsides?

While simple photogrammetry can be accomplished inexpensively, high-end applications can require expensive equipment and intensive computing capacity. Data can take a long time to collect and process, requiring a potentially significant commitment of technological and human resources. While photogrammetry can yield images or models of places that would otherwise not be easily accessible, such images can also easily be rendered incomplete—such as when a drone is unable to take images under a bridge or overpass. Shiny or fast-moving objects are difficult or impossible to capture. Photographic conditions under which data for photogrammetry systems are captured can affect the quality of outputs. Because cameras and photogrammetry software do not capture every nuance or detail of an object, their digital replication can be incomplete and specifications like coloring can be inexact. A certain degree of artistry and effort might be required for optimal fidelity. Industry standards, while evolving, have yet to yield criteria that could lead to more uniformly complete and high-quality imaging. Replicating items can raise significant issues around intellectual property. Photogrammetry can create a false impression that it duplicates a physical object perfectly. If misused, the technology could create intentionally misleading models.

6 Where is it going?

Overall, photogrammetry is becoming better, faster, and more accessible. We are likely to see broader adoption of photogrammetry in general and more use of the technology for more purposes. Photogrammetry is likely to find synergies in the fast-emerging worlds of artificial intelligence and virtual reality. Users will likely collaborate to create increasingly standard data formats that will further speed and scale photogrammetry’s evolution.

7 What are the implications for teaching and learning?

Offering considerable value as a research tool for a wide range of academic disciplines, photogrammetry is growing in value as a tool for knowledge creation and is an important component of the constructivist pedagogy manifest in makerspaces. Also significant is that technology like photogrammetry has the potential to dramatically increase the accessibility of disciplines that were traditionally inaccessible to learners with physical limitations, particularly to partially blind or unsighted learners; technology like 3D tactile gloves, for example, can enable learners to “see” materials that were traditionally inaccessible. The expanding number of courses and programs in photogrammetry points to the growing importance of visual and 3D thinking as elements of digital literacy, akin to the way students work with 2D photographs and processing today.