https://doi.org/10.2352/issn.2168-3204.2024.21.1.20
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Digital Rescue of the Nordic Viking Era

Bjarte Aarseth, The Museum of Cultural History - University of Oslo, Norway

Abstract

Preserving Norway`s Magnificent Viking Heritage: An In-depth Study of Digitization and Cultural Heritage.

This project at the Museum of Cultural History in Oslo, utilizing advanced 3D scanning technology including Tritop, focuses on preserving Norway's iconic Viking artifacts, such as ships and historical objects. Our goal is to preserve and share these treasures, ensuring their legacy for future generations.

This project focuses on creating high-quality digital backups of valuable Norwegian cultural heritage through the surveying of the most irreplaceable and iconic objects, including Viking ships, historical artifacts, church portals, and stave churches. Utilizing advanced technology, particularly powerful industrial 3D scanners, attention is directed towards objects that form the core of Norwegian cultural history. With my background as an experienced master woodcarver actively integrated into the process, emphasis is placed on sensitivity and precision. The goal is to extract maximum information, preserve the unique craftsmanship, and create digital representations of superlative quality. This documentation is shared with conservators, souvenir producers, and the public, both online and through 2D drawings.

The project identifies the most valuable and irreplaceable aspects of Norwegian cultural heritage, while the revenue generated from the surveying proves to be as significant as the costs associated with scanner equipment and labor. This underscores the economic value of preserving and documenting our cultural heritage, forming the basis for a comprehensive strategy for the conservation and dissemination of Norway's cultural treasures to future generations.

Motivation

I began my artistic education early and participated in several exhibitions (freehand drawing), but was most interested in woodwork and sculpture. I obtained my certificate as a woodcarver in 1983 after completing 3 years at art school at the west of Norway. Then I studied for another 2 years at the school of wood carving at Dovre and completed a 3-year apprenticeship at the Viking Ship Museum in Oslo. During trade school, I received training in technical drawing, such as furniture design and constructions, as well as ornamentation. This background has given me advantages, as I constantly emphasize the importance of capturing the construction details in objects during surveying projects. This includes features like dowels and dowel holes, ensuring that all visible dimensions of the object are accurately documented for backup purposes. Understanding the construction and material type (such as wood type) is crucial in this work.

Already in 1906, the archaeologist Gabriel Gustafson, who led the Oseberg excavation, began the work of creating copies of some of the finely carved objects from the Oseberg find. The purpose was to make backup copies in case anything happened to the originals. What was once backup copies safely stored in the storage rooms of the Historical Museum is now almost continuously on loan to other institutions around the globe. This has led to a constant shortage of copies available for loan, especially concerning the animal head posts, making continuous and efficient production of these, desirable. It would also be the best way to maintain the specialized expertise required to create these artworks optimally and in good condition.

The Museum of Cultural History holds the country's largest archaeological and ethnographic collections, featuring artifacts from prehistoric times to the Reformation, as well as ethnographic and numismatic objects from all parts of the world up to the present day. We have over three million items in our collections. Among them are ethnographic objects, Viking ships, medieval church art, the Coin Cabinet, and collections from Egypt and antiquity. The new Viking Age Museum, currently under construction and due to be completed in 2027, will become the world's foremost disseminator of knowledge about the Viking Age. The museum aims to ensure that the population and future generations have access to cultural-historical knowledge and understanding of this unique period of Norwegian history.

The major ship finds from Oseberg, Gokstad, and Tune are among Norway's most important cultural treasures. These ships are the world's best-preserved vessels from the Viking Age, with the Oseberg ship perhaps being the most impressive of them all. Since the excavation of the Oseberg find in 1904, the artifacts have been documented using the best technology available at the time. They were logged and drawn. Pieces of wood, logs, bones, ropes, and metal—all of it lay in mud. Most of it was in a thousand pieces. The wood was soft and fragile. They took notes of which parts they believed belonged to which artifacts, the measurements, decorations, and the type of wood. To trace the details of the woodcarving, pieces of paper were placed over the damp wood and pressed down. The imprint left on the paper was then traced onto the opposite side of the paper. This was the initial method used to visualize the carved decoration. We can still find traces of wood shavings stuck on in this paper from during the process (Figure 1).

Figure 1. *Traising of detalils, year 1904. Paper is pressed against the*

wet surface, and the "stamp" is traced on the opposite side. There are still remnants of the orginal wood on the paper. Photo B. Aarseth

Sketches were made, for example, of the Oseberg wagon. The Oseberg wagon is the only wagon found from the Viking Age in Norway, and the only one in the whole world. It dates back to before the year 800. The wagon body, which sits loosely on the chassis, is decorated with depictions of human heads and people in battle with snakes and strange animals. The sketches from the excavation were redrawn and published in the comprehensive work on the Oseberg find. Taking pictures in 1904 was expensive, which is why there are hardly any photos of the wagon as it lay in the mud. The original wood was restored, and it was a big puzzle to get the right parts in the right place. The museum's draftsmen created the floor plan showing both the parts individually and together, but the floor plan has an inaccurate scale and is very idealistic. Eventually, the wagon was documented through black-and-white photographs. However, as early as 1906, woodcarvers were employed to create replicas of the objects in the grave. These were to serve as backups in case the originals were destroyed. The methods used to preserve the wood over 80 years ago have had serious side effects, as they chose to soak the wood in the chemical compound alum. It was the best choice in 1904, but it came with preservation problems later on. Over the course of time, part of the so treated wood has become as brittle as crackers.

Challenge

At the Viking Ship Museum, I apprenticed under a master woodcarver who taught me about Viking Age ornamentation, tools, and techniques for creating wooden sculptures using traditional methods. Learning to replicate animal head posts from the Viking Age, as wells as large solid oak sculptures from the Middle Ages using original production methods, was invaluable. Understanding wood technology and how curved and crooked wood was used for sculptural elements, such as animal head posts, during the Viking Age, was a useful experience. This is what I try to incorporate into surveying projects involving wooden objects or elements. Determining whether the wood is straight-grained or not is essential, even if the surface has been treated. The significant advantage is that we can later manipulate the lighting in 3D scans. These details should be visible. During my apprenticeship as a woodcarver at the Viking Ship Museum, we also worked with freshly cut or air-dried wood for sculptures. This taught me a lot about how wood behaves and the cracks that can occur, therefore, I actively use the Probe (GOM Touch Probe) in conjunction with the scanning project to mark the depth of cracks in the 3D scan. Working with measurements on irreplaceable and fragile iconic objects led me to search for non-contact measurement techniques.

Approach

Project 1985: The Laser Pen Method. A practical approach was needed. This method, which I developed as an apprentice at the Viking Ship Museum, is actually still in use in Norway. It involves tracing the outline of all five sides of an object. The object must be placed on a table with a glass plate suspended above it (20 - 40 cm). A carpenter's square with a mounted laser pointer pointing vertically downwards is then used (Figure 2). The angle of the square is adjusted on the glass plate, and where the laser dot intersects the object below, a mark is made on the glass plate. This allows for tracing the outline and details of the object from a top-down perspective. Once this is completed, the process continues to trace the object from all other sides. If the object is not enclosed in a glass case or display, the glass plate needs to be moved accordingly.

Figure 2. My former woodcarving apprentice Boni Wiik is tracing a sculpture with The Laser Pen Method, 2024. Photo Boni Wiik

Project 1995: Laser scanning of a painted wooden dragon from an altar piece. The test involved scanning the dragon to create a digital model. My challenge was to replicate this dragon in the same material (oak wood) without having seen it. My only tool was a 540 KB floppy disk. I initially attempted using AutoCAD, but the project was partially unsuccessful until 1998 when I tried again with Rhinoceros version 1. Even then, I could only partially recreate the dragon as I still lacked sufficient data to make an exact replica in wood

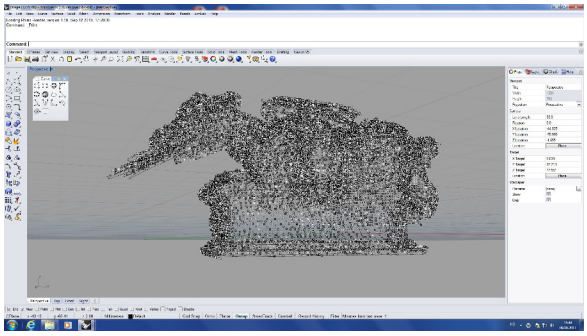

Figure 3. Laser scanning of a painted wooden dragon from an altar piece in Førde church from 1643 AD, Screenshot Bjarte Aarseth

Project 2009: Small tests with different scanning technologies. Used a replica of an intricately carved animal head post as a test object, where 3D scanning with structured light performed the best. We were primarily interested in the geometry, while capturing texture on the surface was less important.

Project 2010: I was entrusted with the responsibility of digitally surveying the ridge fields of Urnes Stave Church (from the year 1000) and the tower rider of Borgund Stave Church (from the 12th century). This was a commission from the Norwegian Directorate for Cultural Heritage, motivated by the presence of scaffolding around the churches, which could serve as scanning platforms for both scanning objects positioned 10-20 meters above ground level. The surfaces were coated with a black and glossy tar. The assignment was organized by the Norwegian Directorate for Cultural Heritage, and since there were no structured light scanners in Norway, a company from Sweden was hired. Following my recommendation, the Directorate for Cultural Heritage tested out this type of scanning. I was asked to participate as an assistant because the Directorate saw my background as a woodcarver as valuable – also considering the possibility of my skills to recreate these parts in wood. So that as much of the craftsmanship as possible was to be preserved, for example tool marks. My experience after this project was that I had found the optimal surveying system capable of capturing glossy surfaces without the need for contrast sprays. The system we utilized was the Atos 3D scanners with TRITOP.

Figure 4. *Year 2010, 3D-scanning the carvings on the top of the Urnes Stave Church (year 1000 AD) Photo Bjarte Aarseth*

Project 2013: Now I am embarking on a full-time digital surveying of objects at the Viking Ship Museum. After conducting tests, the Museum of Cultural History purchased Atos Compact Scan MV/SO, MV500, and MV1200 scanner. The task has been to create actual backups of the museum's objects, but this work is transitioning towards creating digital backups. The advantage of this scanning technology is that all shiny metal parts on the objects are captured by the 3D scan. These can include metal fittings or nails made of gold, silver, bronze, etc.

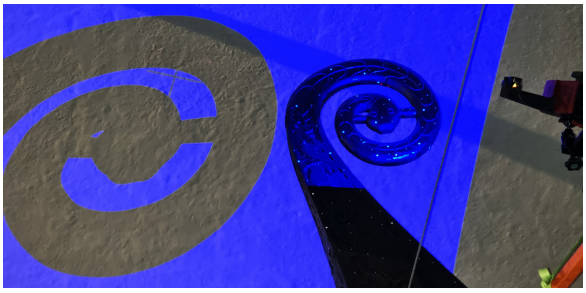

Figure 5. *Year 2013, 3D-scanning of The Oseberg Ship (830 AD) Photo Bjarte Aarseth*

Process and results

Now we have obtained precise and accurate measurements of the objects and KHM has invested in several GOM Scanners. The museum has been emptied of objects due to the construction process of the new museum, and in this context, all objects were 3D scanned + TRITOP. During the dismantling process, the Oseberg wagon was 3D scanned with extremely high resolution. Scanning with such high resolution also reveals new details in the decorations, leading us to discover new things that we haven't seen before. These are new ornaments in the carvings and runic inscriptions on the objects. All of this is now being documented in the surveying project of the Oseberg wagon. It must be emphasized that when the surface is so fragile, fixed points for TRITOP were placed around the object and not on the surface. For example, I created a frame around the outside of the wagon body where I placed the reference points. This frame did not touch the wagon body.

Users. In principle, the surveying projects are backups, but we continually discover new applications for them. For example, with the Oseberg ship, we can observe movements in the wood when overlaying the latest project´s version onto the first and original project. This is very valuable information for conservators and mount makers. It's also very practical to see it in 3D.

Surface changes - UV exposure

To my surprise, I discovered in 2014 that changes in the surface of tar-treated objects were detected by the 3D scanner even when neither I nor conservators could see them with naked eyes. Both the Oseberg ship and the Gokstad ship are black and have been tar-treated, which is still visible on the ships. The side of the ships exposed to UV radiation in the exhibition (direct sunlight through windows) was shinier than the side that had been in the shade. This significantly affected the time it took to scan the shinier side as I needed more scanner positions to capture the surface. This is valuable experience that I am carrying forward when working on surveying projects of stave church portals or tar-treated objects. There is a difference between the "sunny side" and the "shady side". After my discoveries at the Viking Ship Museum, UV filters were installed on the windows.

I will here provide an example of two projects for which I have conducted surveying. Project The North Wall Urnes Stave Church. This stave church, where the parts on the north wall date back to the year 1000 AD, is on UNESCO's World Heritage List, and the church is treated with tar on its original wooden surfaces. The assignment from the Norwegian Directorate for Cultural Heritage was to 3D scan both the interior and the exterior, including the Urnes Portal and all the side planks with carvings. The Urnes Portal stands on the north wall of the current church but was originally the west portal of an earlier church that stood there. Remnants of a couple of generations of churches have been found at the same location before the construction of the current one, which was built in the 1130s.

The north wall of a building is the side most sheltered from the relentless degradation of the sun, and the placement of the Urnes Portal here, may also suggest a desire to preserve these beautiful architectural elements as much as possible. The

church is the only one of the stave churches to have made it onto UNESCO's World Heritage List, and this is probably mainly due to this portal, although 'portal' may be a somewhat underestimated term. The earliest churches from the missionary period in Scandinavia were probably more decorated on the outside than the later stave churches we know from the 1100s onwards. The entire north wall of Urnes Stave Church has wall tiles and corner posts as well, which were part of a rather monumental west front, with continuous embellishments from corner to corner, through the portal, and also with the entire tympanum field in the gable, carved out with the same ornamentation.

The door in the portal is the only stave church door known that is also carved. The ornamentation follows the rest of the embellishments and is an integral part of the entire gigantic ornamentation composition that this must have been at some point. The north wall is 14 meters long and 4 meters high, so it was a challenging task to scan, yet very successful. In the project, one can get the inside and outside in the same 3D scan. The method I used was to use common points from the doorway at one end of the wall to a small window at the other end, and this was enough to merge the projects from the inside and outside. The portal was 3D scanned with an Atos Q MV270, which has a point density of 0.064mm. It is very unusual to use structured light scanning on such a large project, but due to the black shiny surface with intricate carvings, this was the only option.

Figure 6. *Project 3D-scan of the North Wall Urnes Stave Church. Date back to the year 1000 AD, is on UNESCO's World Heritage List. Photo Bjarte Aarseth*

The second project is of an animal head post from the Viking Age, 830 AD, There were five animal head posts in the Oseberg find. They depict the heads of dogs. Such posts are not known from anywhere else. Four of these artifacts were located in the burial chamber, while one was found in the forepart of the ship. They are about 50 cm tall and have a shaft at the bottom. Perhaps they were intended to be carried, attached to the wagons or sleds, or maybe they belonged to the high seat? They are too small to be prow decorations for ships. One of them was found with a rope through its jaws, which was attached to a so-called rattle. There were numerous undercuts and cavities, making 3D scanning of this object a significant challenge. In total, I used 2200 scanner positions, perhaps making it the project in the world with the highest number of scanner positions executed following structured light scanning.

Conclusions

After working full-time on the measurement of objects using 3D scanning and TRITOP, I've found that experience is invaluable. Working full-time with the equipment allows you to develop it in a different way than if you only use a 3D scanner occasionally for specific projects. Continuity is crucial for becoming proficient enough to handle all types of surfaces. Objects made of wood, metal, stone, porcelain, etc., all pose their own challenges and reflections. This is what makes the workday exciting, and documenting fragile national treasures with 3D scanning and TRITOP is a significant responsibility. Having a background as both an artist and a craftsman operating a 3D scanner is something I consider a significant advantage. As an artist, there's always a drive to progress, and the next project, if possible, should be better than the last.

2D-drawings

Being able to produce documentation drawings/production drawings based on 3D scans is something I consider extremely important. I have significant experience using Rhinoceros 3D to create a curve around objects when laid flat, as it allows me to better visualize ornamentation/design. This has helped me several times when the object has a cylindrical shape.

3D-scans

3D-scanning provides the ultimate basis for achieving high accuracy and precision down to one hundredth of a millimeter, and in the right software, one can control the lighting direction to capture more details. My background in drawing allows me to spot objects or details on the surface of objects that can be illustrated. These illustrations can later become a source of revenue for the institution I work for. As of today, the institution I work for has patented around ten illustrations that I have created based on 3D scans.

Souvenir production and 3D printing.

I have extensive experience collaborating with the institution's souvenir shop on prototypes for souvenirs. I strive to achieve high quality in the items sold there, and my illustrations can certainly contribute to that goal. Additionally, I have expertise in utilizing 3D printing technology, which further enhances our ability to create unique and detailed souvenir items. This not only helps in outwardly communicating our history effectively but also ensures a pleasant source of income for the institution.

WEB

We are inputting 3D objects into the Unimus portal for KHM. The viewer is specifically designed to take physical measurements of an object.

In 2015, together with an external inventor programmer we received a price in "Improved 3D visualization for web sites" by the University of Oslo. The price aims to provide recognition and stimulate research-based innovation and entrepreneurship. It is awarded based on ideas that have emerged at the University of Oslo (UiO) and have been applied

in society, often in collaboration with external partners. The software caught the attention of the private sector as well.

Tool/Scanners

Atos Q MV100	*0,029mm (12MB)*
Atos Q MV270	*0,064mm (12MB)*
Atos Q MV500	*0,124mm (12MB)*
Atos Core MV45	*0,018mm (5MB)*
Atos Compact Scan MV1200	*0,292mm (12M)*

Resolution on objects: Osebergship and Gokstadship, glossy tar: Atos Compact Scan MV1200 and on the carving bow and sternpost Atos Q MV270 and MV100

On reflective metal as gold and silver Atos Q MV270, MV100 and Atos Core MV45

TRITOP camera: Cannon EOS 5D SR, Titanar 25 and Zeiss Makro Planar 67mm lens

GFX100 FUJI camera, 120mm lens

GOM Touch Probe (fig 7): The GOM Touch Probe comes with five probe heads in different sizes, suitable for small to large objects. It is designed in a way that makes it adaptable for various applications and objects. Users can not only easily exchange probe heads and extensions but can also construct custom touch probes for specific measurement tasks. For this reason, the GOM Touch Probe is suitable for measuring cracks as well as constructions for large objects. Examples of sculptures may include areas that are impossible to reach, such as ear canals, nostrils, etc. The GOM Touch Probe and CMM adapters expand the possibilities of measuring geometric elements online using ATOS sensors. For this purpose, the sensor continuously captures and tracks the movements of the optically tracked accessory. The software provides me with continuous feedback about the current position (fig. 8). The measurement is triggered manually, and only the measured value is saved in the software.

Figure 7. *The GOM Touch Probe. I can mark the depth of craks and plug holes in the project. This example is from the Hylestad portal. Photo Bjarte Aarseth*

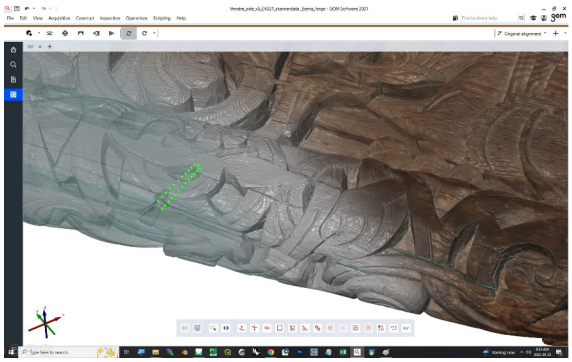

Figure 8. *The GOM Touch Probe. The tool allows me to draw in the project. Photo Bjarte Aarseth*

TRITOP stands as a cutting-edge mobile optical measuring system renowned for its precision in defining the 3D coordinates of object points, particularly under quasi-static conditions. Leveraging advanced optical photogrammetry technology, TRITOP excels in capturing intricate data sets, facilitating meticulous measurements of 3D displacements and deformations across various objects and components. This capability not only provides invaluable insights into the structural integrity and behavior of the measured entities but also serves as a fundamental tool for engineers, researchers, and professionals across a spectrum of industries, and TRITOP is really important for to get a perfect project. With its robust performance and versatility, TRITOP plays a pivotal role in driving innovation and ensuring quality assurance in modern engineering and design practices.

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Author Biography

I am responsible for initiating the 3D scanning project at the Viking Ship House in 2013, and for its development into a leading entity within the field in Europe today.

I have a background in art (drawing) and hold a journeyman certificate as a woodcarver specializing in sculptural work in wood, and I have also served on the Master Certificate Board.