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The Indian sculpture enhanced by Augmented Reality and Reflects changing fashion represented in the ornaments and culture

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Abstract

Digital technology is developing and being used so quickly that it is becoming common to use these new technologies to produce sculptures. The robust technological innovation that underpins modern sculpting art is directly linked to its quick evolution. Thus, it is inevitable that sculpture and current technology will be combined. This research suggests combining three-dimensional modeling, augmented reality applications, and photogrammetric reconstruction to visualize a stone sculpture in its entirety, even if it is severely damaged or fragmented. The first section of the study attempts to create a first model of an incomplete sculpture by reconstructing its original feature by utilizing photogrammetry approaches based on software and standard-resolution images. Subsequently, to preserve the original feature of the sculpture, we looked into ways to combine the model with additional 3D digital data gathered from different sculptures from the identical era or use 3D modeling according to past information and historians' perspectives. Three Dimensional temple sculptures are imported into Augmented Reality software. The subsequent study phase integrates the acquired model into a custom application to produce a real-time 3D recreation of the stone sculpture. A full 3D digital model of the sculpture is then produced and may be viewed using a virtual reality viewer by superimposing the rendering over the real scenes video feed. Many artists are interested in using virtual reality technology to create sculptures for art performances. To provide guidance and support for the fusion of virtual reality and sculpture, this article addresses the advantages of employing virtual reality technology for making sculpture, looks at the way the characteristics of virtual reality impact sculpture, and provides an outlook on fashion as it manifests in culture and ornaments.

Keywords: Indian sculpture, Ornaments, Culture, Photogrammetric restoration, 3D modelling, Virtual Reality

1. Introduction

Sculptors and artisans have employed nearly every material known to man to produce sculpture throughout history. It has been possible to mold clay, carve wood, hammer or cast metal, and chisel stone. Knives have been used to form ivory, bone, and resins. Skins are stretched into shape, and reeds are packed. Contemporary industrial and space-age materials like exotic metals, composites, and plastics have joined the sculptor's ever-expanding toolkit at the start of the twenty-first century. Environmental forces can cause degradation, corrosion, and destruction to all sculpture materials, even though many show more resilient and long-lasting than others. Many intricate factors inform the conservator's strategies for mitigating this degradation. Both the sculpture's previous and future environments and the material's inherent qualities are relevant. Another factor to consider is how much the sculpture had previously degraded before conservation or repair. Several values (financial, religious, cultural, historical, and aesthetic) may significantly impact the conservator's decision on the sculpture's conservation and preservation and its original or purposeful usage. The fundamental physical characteristics of GFRP and regularly utilized metal materials for sculpture making are contrasted in **Table 1 [1-5]** and **Table 2 [6-9].**

Table 1. The fundamental physical characteristics of GFRP and regularly utilized metal materials for sculpture making are contrasted (Type-1)

Material	Thermal Expansion Coefficient (10^{-6}/°C)	Elastic Modulus (Gpa)	Tensile Strength Mpa	Density g/cm^3
Iron	11.6~12.1	151~160	220~260	7.83~7.87
Stainless Steel	6.4~10.4	190	>520	7.75~7.93
Copper	7.8~9.8	90~130	200~360	8.92~8.96
Glass fiber-reinforced plastic (GFRP)	2.7~7.2	10~25	>150	1.4~2.5

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Table 2. The fundamental physical characteristics of GFRP and regularly utilized metal materials for sculpture making are contrasted (Type-2)

Material	Solid Content (%)	Acid Value (mg KOH/g)	Shrinkage 25 °C (%)	Viscosity 25 °C (Pas)
Epoxy resin	68~72	30~40	1.8	0.60~0.95
196# Unsaturated resin	60~70	17~25	2.1	0.65~1.15
191# Unsaturated resin	67~75	16~36	1.6	0.25~0.45

The slowed down of any deterioration may be ensured by maintaining stable and appropriate humidity and temperature levels and creating an atmosphere free from contaminants, light, and UV radiation. Additionally crucial are routine cleaning, primary sculpture care, and watchful measures to keep harmful insects at bay. In sculpture, there are four primary methods: casting, modeling, assembly, and carving. **Figure 1** illustrates the fundamental carving processes. After studying it, the artist creates the model using clay or wax and scales to suit their needs. Following this procedure, the material is carved by a craftsman who locates the artifact's 3D coordinates **[10].**

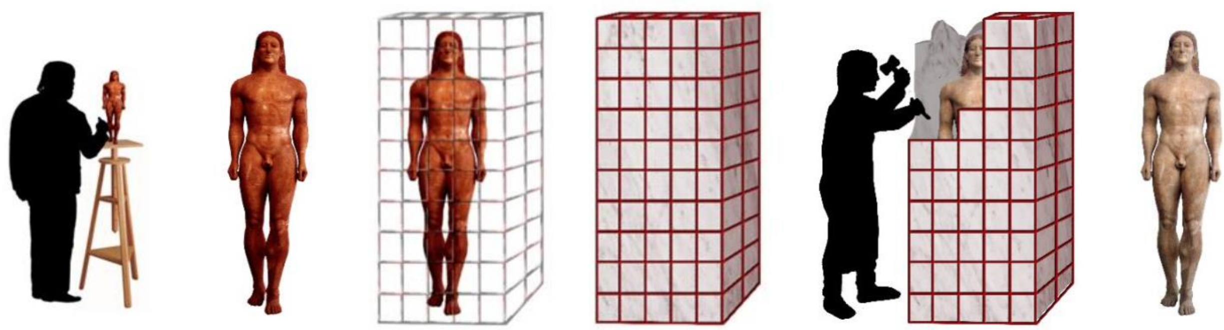

Figure 1. Fundamental procedures for carving approach

The basic processes of the lost-wax casting approach are depicted in **Figure 2.** The artist creates the model using clay or wax, and following examination, it is designed to the desired scale. An artist crafts the sculpture's mold as the next stage of the procedure**.** The fundamental stages of the lost-wax casting process are also depicted in **Figure 3**. A wax shell of the identical statue is then created by the craftsman pressing wax (7–10 mm) into the mold. Subsequently, the artist

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constructs a system of wax tubes that serve as the exit points for the melted metal and wax, filling the void without containing air. To guide the wax out of the body and the metal in, the wax tubes in the above instance are positioned inside and outside the body. The two systems are typically found inside the body of a life-size statue.

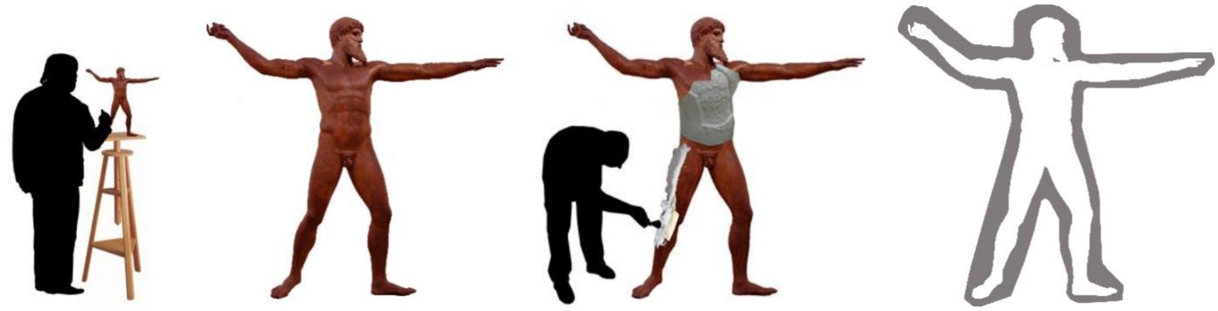

Figure 2 Fundamental procedures for casting in lost wax (Method-1).

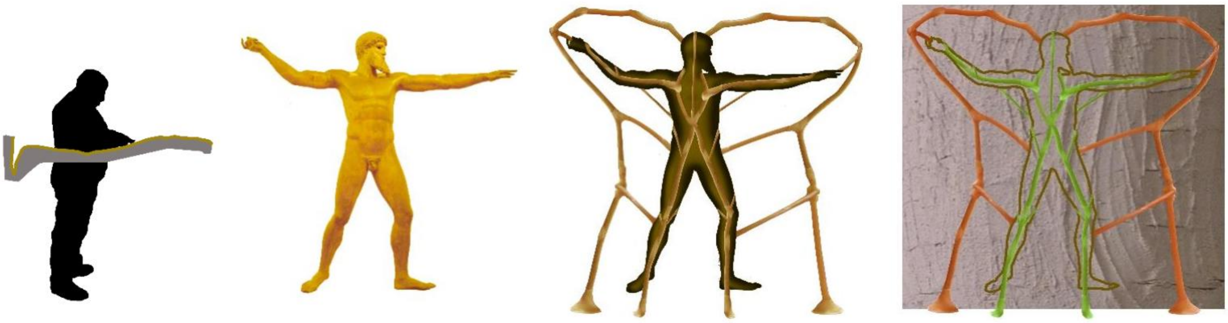

Figure 3 Fundamental procedures for casting in lost wax (Method-2).

It is crucial to preserve historical objects and sculptures to preserve cultural heritage and carry it on to future generations **[11].** Photogrammetric reconstruction, 3D modeling, and augmented reality are used for preserving hardwood polychromatic sculptures. Initially, only paintings are subjected to digital photogrammetry to examine the surface layers **[12–13].** Near-infrared photography can be captured with the Samsung Model NX3300, whereas ultraviolet fluorescence photography is captured with the Nikon D5300 digital SLR camera **[14].** The most popular digital terrestrial cameras (weight is considered without lens) are displayed in **Table 3**

Table 3. The most popular digital terrestrial cameras (weight is considered without lens)

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Camera Name	Type	Sensor size (mm)	Sensor Type/ Resolution (Mpx)	Shutter speed	Frame rate (fps)	RAW file (bit)	Weight (kg)	Pixel size(μm)
Panasonic Lumix DMC-GH2	Micro four Thirds system	18.9 × 14.5	Live MOS / 16.1	1/8,000	5	12	0.394	4.1
Olympus E-PL2	Micro four Thirds system	17.× 13	Live MOS / 12.3	1/8,000	3	12	0.317	4.3
Sony αNEX-5	APS C	23.5× 15.7	CMOS / 14	1/8,000	2.3	12	0.287	5.1
Sony α900	35 mm full frame format DSLR	35.9× 24	CMOS/ 24.6	1/8,000	5	12	0.895	5.9
Nikon D3X	35 mm full frame format DSLR	35.9× 24	CMOS / 24.5	1/8,000	5	14	1.260	5.95
Canon EOS-1Ds Mark III	35 mm full frame format DSLR	36 × 24	CMOS / 22	1/8,000	5	14	1.385	6.4
Mamiya DM33	Medium Format DSLR	48 × 36	CMOS / 33	1/8,000	1.1	16	1.63	7

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Pentax 645 D	Medium Format DSLR	44 × 33	CMOS / 40	1/4,000	1.1	14	1.48	6
Hasselblad H4D-60	Medium Format DSLR	53.7 × 40.2	CCD / 60	1/800	0.7	16	1.8	6

Photogrammetric reconstruction, 3D modeling, and augmented reality techniques are all suitable for restoring destroyed sculptures. One of the most critical steps in restoration is documentation, the first necessary procedure before and after regular operations **[15–21]**. The standard UNI EN 16095 **[22]** states the importance of documentation and status records, encompassing gathering information, documents, graphics, and photos. The state/condition document has historical significance and is logically and well-organized, containing all pertinent and necessary information **[23].** Two-dimensional methods, such as pictures, written notes, and graphical maps, are frequently used in the documentation phase of restoration projects to document artifact and item alterations, deterioration, additions, sampling points, and other details. Nonetheless, there are certain benefits to using 3D digital models, particularly when it comes to sculptures and other 3D items [24–26]. By rotating the models, the 3D models make viewing the entire object surface possible and send all the data in a single file. UV fluorescence and IR photography are frequently used in the documentation stage of conservation procedures to provide further details about the restored artifact [27]. Photographs with information about constitutive and repair materials—which typically react differently to UV radiation—can be captured using UVF photography. Since it provides conservators with an understanding of original and restored materials, the information gained from these data is critical to restoration work. As a result, it serves as a valuable tool for cleaning procedures that often target removing overlaid or unclean layers. The effect is primarily associated with organic materials, while inorganic materials are also linked. Moreover, since fluorescence intensity increases with age, contemporary materials exhibit less fluorescence and appear darker than ancient materials [28–29]. Regarding 3D artworks, the conventional method of obtaining UVF frames may be a constraint due to the challenge of displaying the details spread across many focal planes in a single 2D photogram. This limitation may be overcome by employing UV rendering and three-dimensional photogrammetry, beginning with UVF images captured with

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a conventional camera and processing utilizing Agisoft PhotoScan software [30–32]. To find concealed pentimenti, underdrawings, signatures, and other elements in paintings, infrared photography is also frequently employed during the documentation stage of the restoration process [33–35]. However, to our knowledge, this method has never been used on sculptures to create 3D models when exposed to infrared light. Digital photogrammetry is an inexpensive technique that starts with still photos and lets users make 3D representations of cultural heritage items [36–45]. This technique can achieve accuracy down to the millimeter using appropriate and established protocols [46–48]. Software for Augmented Reality imports 3D temple sculptures [49]. Recently, the swift advancement of networks and computer technology has dramatically enhanced people's quality of life on a technological level. Simultaneously, people are growing increasingly accustomed to using computers. Individuals may achieve more significant and vivid objectives more readily and easily through human-machine interaction. AR/VR technology is a new immersive technology that has become a part of people's everyday lives [50]. Users' perceptions of actual-life situations can be enhanced by fusing computer-generated virtual surroundings with real scenes through AR/VR technologies. Since virtual reality (VR) technologies are more suited to people's needs and immerse users in the actual world whenever they interact with virtual settings.

2. Literature Reviews

Digital technology has a variety of applications in the subject of cultural heritage, including monitoring, measuring, digitizing, and visualizing. Observing and studying historic buildings or artworks prompts using 3D models from a diagnostic standpoint to examine structures' true size, stability, changes over time, and other details [51]. With the advancement of measurement technological advances, information that was formerly exceedingly challenging and potentially hazardous can now be gathered and processed with a digital camera and commercial software. Various structures can be effectively and economically modeled using digital close-range photogrammetry [52]. Additional uses of photogrammetry include restoring digital models using photographs gathered from the internet [53–54], such as when reconstructing the appearance of severely damaged or destroyed artifacts. Digital tools that help stone carvers restore carved elements undergo evaluation [55]. At the same time, the sculptors and masons teach us about their methods so we can better comprehend how they conserve and restore sculptures. As demonstrated by [56], improved technology and software, even free or open-

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source, have made photogrammetric methods more crucial for most of these goals in recent years. Despite the presence of low-textured or reflecting surfaces in the 3D scene, they concentrate on the precision and metric content of the output, which is universally acceptable. Augmented reality (AR), 3D printing, and scanning are a few innovations employed to recreate and display the intricacy of the region and its history [57]. While certain museums and archaeological sites have begun to use digital tools to help conserve and promote their legacy, only some interactive services still provide visitors with a more contemporary and immersive experience. Because of its affordable price and versatility, photogrammetric software is increasingly utilized in cultural heritage preservation to model complicated figures as a substitute for 3D scan-based approaches [58]. The researchers used this approach to model a piece of “Mesoamerican sculpture”, the “Chacmool of Tenochtitlan”, to acquire an accurate 3D model or an exhaustive record of its present condition. It was then utilized to construct interactive museum models and create stereoscopic videos.

3. Methodology

To create an initial model, the initial portion of the study attempts to investigate how to reconstruct a damaged sculpture utilizing photogrammetric approaches using standard quality/resolution pictures and, if feasible, free software. Next, using photogrammetry to identify and digitally reconstruct various sculptures from the same time frame, as well as 3D modeling based on archaeological research and art historians' hypotheses is studied, the methods to incorporate the missing components of this model are understood and learned about the ways to work towards restoring the damaged sculpture to its original physical appearance.

4. Restoration of damaged Stone Sculptures

This study examined photogrammetric and augmented reality technologies to recreate and integrate the missing portions of stone sculptures. The damaged sculpture is initially "augmented" using digital models that are taken from and modified into similar sculptures, after which it is digitally rebuilt and incorporated with the missing pieces.

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Figure 4 Damaged Lion statue

Figure 5 Photogrammetric reconstruction receives the input photographic images

This study examined photogrammetric and augmented reality technologies to recreate and integrate the missing portions of stone sculptures. The damaged sculpture is initially "augmented" using digital models that are taken from and modified into similar sculptures, after which it is digitally rebuilt and incorporated with the missing pieces. The process

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necessitates reconstructing several models, all of which must be compatible with the damaged one concerning the stone's color, texture, and surface finishing. In addition, the parts and their features must be meticulously worked on. **Figure 4** shows the damaged Lion statue, and **Figure 5** shows the Photogrammetric reconstruction receives the input photographic images.

Figure 6 The reconstruction of digital model

Figure 7 The sculptures from the identical era

Research on art history and archaeology suggests that to identify the "missing parts," it is necessary to examine and analyze models with similar features. Because of photogrammetry,

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the technique's lighting settings may be crucial, necessitating post-processing of the photographs to get superior outcomes.

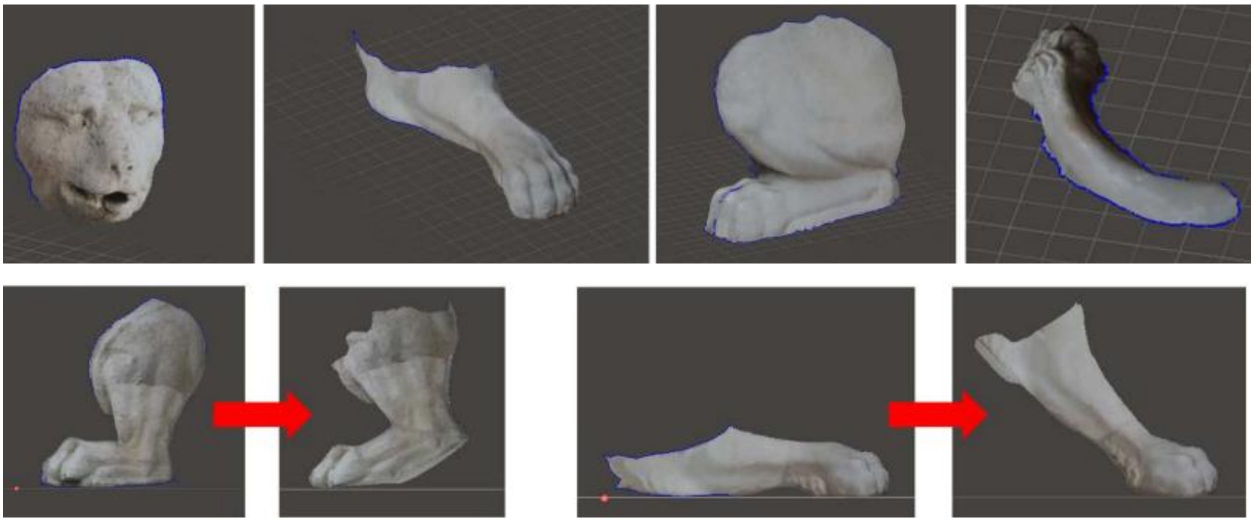

Figure 8 3D digital data gathered from different sculptures from identical eras or using 3D modeling according to past information and historians' perspectives

Figure 9 A 3D model of the lion

Figure 10 An AR scene of the lion

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A dual rendering pipeline is needed when using a VR viewer, requiring the scene to be rendered twice. This can be a significant issue for highly complex scenes, necessitating the reduction and simplification of the virtual model. Conversely, the approach can produce a tool that provides the viewer with augmented reality visualization and allows for evaluating potential reconstructions of damaged sculptures. As a next step, we'll use augmented reality to incorporate the rebuilt lion into the overall scene of the monuments. **Figure 6** displays the reconstruction of the digital model, and **Figure 7** shows the sculptures from the identical era. 3D digital data gathered from different sculptures from identical eras or using 3D modeling according to past information and historians' perspectives is illustrated in **Figure 8. Figure 9** depicts a 3D model of the lion, and **Figure 10** is an AR scene of the lion.

5. Changing fashion represented in the ornaments and culture

To provide guidance and support for the fusion of virtual reality and sculpture, this article addresses the advantages of employing virtual reality technology for making sculpture, looks at the way the characteristics of virtual reality impact sculpture, and provides an outlook on fashion as it manifests in culture and ornaments. **Figure 11** shows the augmented reality technique reflecting the culture and accessories' changing fashion. The procedure for digital preservation, 3D reproduction, and interpretation is schematically presented in **Figure 12.** The Legend of patterns, which depicts various forms of damage and other situations, is displayed in **Figure 13. Figure 14** illustrates the scientific approach to the sculpture's reconstruction.

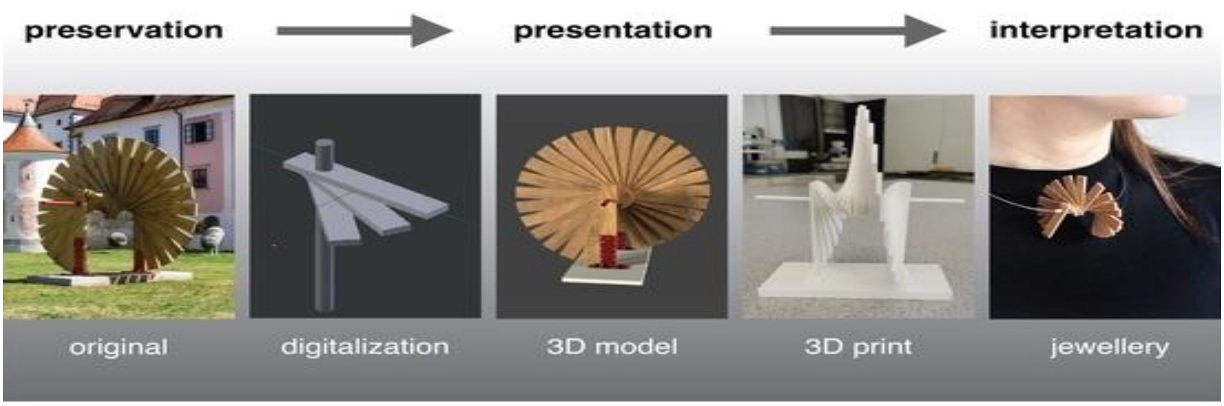

Figure 11 The augmented reality technique reflecting the culture and accessories' changing fashion

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	DIGITIZATION	IMAGING / REPRESENTATION	3D PRINTING
CONSERVATION APPROACH documentation and detail describing of sculptures	SKETCHING measuring	2D / 3D VIZUALIZATION OF DAMAGE (teksturing with new patterns on 2D / 3D models)	
TECHNOLOGICAL APPROACH production of "authentic„ digital and printed reproductions of sculptures	3D MODELING (accurate) PHOTOGRAMETRY - dron - digital camera	VIZUALIZATION (teksturing) retopology	SCULPTURAL PROTOTYPES post-processing Materials: ▪ thermoplastics ▪ photopolymers ▪ metals
DESIGN APPROACH creative interpretation of sculptures	3D MODELING (creative) conceptual studies visualization on the body	DIGITAL ANIMATION (skulpture / narration) various animation techniques	JEWELERY post-processing

Figure 12 The procedure for digital preservation, 3D reproduction, and interpretation is schematically presented

Figure 13 The Legend of patterns, which depicts various forms of damage and other situations

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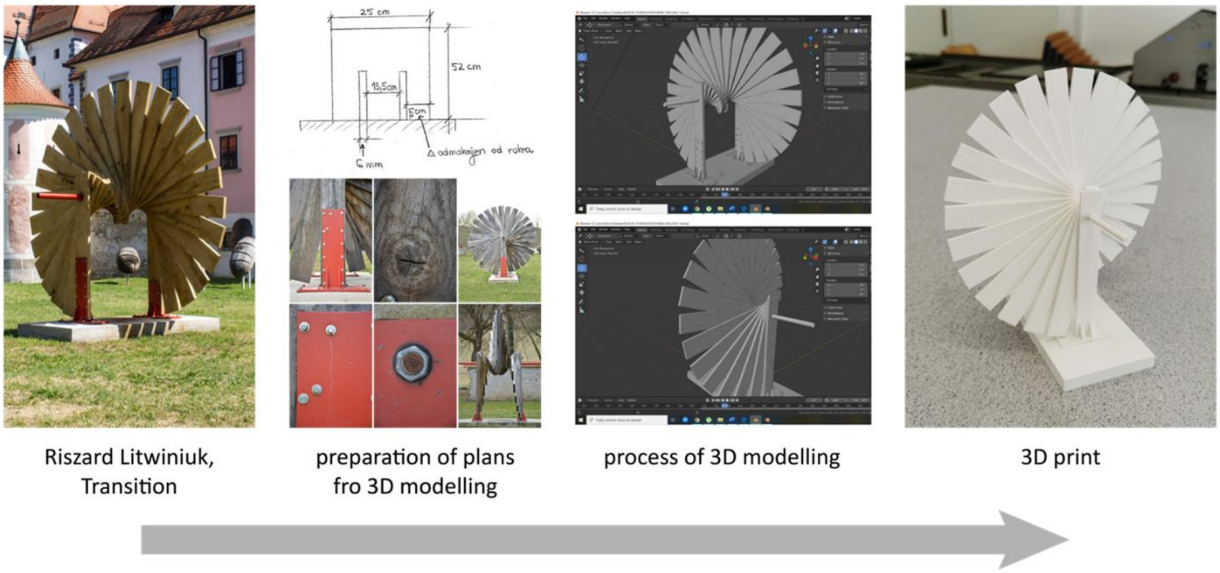

Figure 14 The scientific approach to the sculpture's reconstruction.

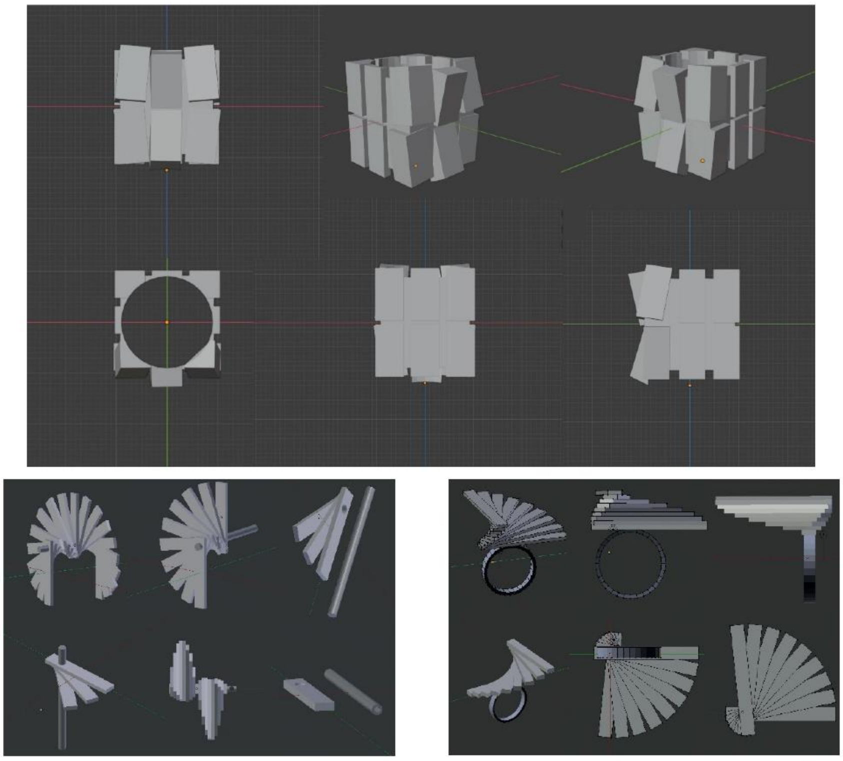

Figure 15 The 3D models of jewelry created.

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Figure 16 A line of jewelry created with discarded wood and polymer

Understanding the monument and converting its idea into a piece of other material art with the identical intent to communicate with the observer or user was the aim of turning a sculpture into a jewelry collection. Apart from producing small-scale copies of artwork, it was intriguing to develop novel and imaginative items that art galleries may provide as a component of their sales initiative. We have, therefore, transformed the creative discipline of sculpture into the artistic domain of original jewelry. Because of their accuracy and superior material quality, modern 3D printing methods from newer materials, particularly metal alloys, are perfect for producing jewelry, whether one-offs or microseries. To investigate how the two chosen sculptures might be interpreted in a jewelry line, the design process started with analyzing the works from a visual, conceptual, creative, and production standpoint.

Figure 17 A ring made using metal powder.

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Furthermore, it was crucial to understanding modern jewelry design. As a result, we concentrated on conceptual jewelry design, where the idea behind a piece is more valuable than the forms or materials employed. According to concept jewelry designers, the goal of a piece of jewelry is to elicit strong feelings from both wearers and spectators. Preliminary sketches of concepts for design are the first step in the design procedure. The jewelry's size and form must consider the human body's curves and be modified as needed. The jewelry is then 3D modeled using the Blender software to complete the procedure. After the jewelry's intricate 3D models were created, they needed to be precisely measured and ready for 3D printing using the selected technologies. **Figure 15** shows the 3D models of jewelry created. A line of jewelry created with discarded wood and polymer is shown in **Figure 16** and **Figure 17** shows a ring made using metal powder.

6. Conclusion

Nowadays, digitizing sculptures is an essential and time-consuming execution process. Current technologies have simplified work. Augmented reality is one of these technologies. Three-dimensional sculptures can be seen in a real-world setting using augmented reality. Software for augmented reality is utilized to import three-dimensional temple sculptures. Photogrammetry is used to construct these three-dimensional structures. Using photogrammetry, exact 3D models can be created. Comparing photogrammetry to other methods, such as 3D scanning, it is less expensive. Plus, photogrammetry is inexpensive. First, to gather data, the photogrammetry process requires sculpture images. All possible views of the sculpture are captured in the photos. Indian sculptures are vital to humanity's shared cultural legacy, carrying millennia of wisdom and experience. The sculptures can sustain many kinds of harm and become misshapen over time. Historical artifact documentation is essential for tracking these alterations and ensuring restoration efforts adhere to the original design. For the thorough digitization and visualization of sculptures, high-accuracy 3D models are required. There is room for an investigation into the extraction of these features and the geometrically accurate modeling of the sculptures. While new technologies cannot replace authentic artworks and sculptures, they can significantly enhance conservators' ability to inspect, record, and evaluate their state. Selected sculptures underwent a variety of 3D techniques, which provided information for the documentation process that forms the foundation for preservation planning.

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Before any intervention, 3D representations offer more thorough documentation of the physical composition and state of the artworks at a specific moment (proof of their history). Conservationists can visualize some data with 3D graphic demonstrations that aren't always feasible with traditional 2D demonstrations. However, using these presentations calls for novel expertise, skills, and equipment and sometimes requires working with other experts. Additionally, digitization enables us to maintain at least the metadata of artworks that, for various reasons, cannot be preserved physically. While protecting an artist's intellectual property, high-quality information might be provided (digitally) and accessible to specialists for investigation or the general public globally to promote artworks in many ways. In addition to giving the sculptures new life, we also enhance the narrative about the sculptures with our interpretations of the sculptural work and the form and expression of the sculptures by employing interpretative approaches that led to jewelry in our study.

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