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# Reverse Engineering for Restoration and Preservation of Old Artifacts and Cultural Heritage

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***Abstract:*** **India is a country with a rich cultural heritage. The historical heritage dates back to centuries from primitive times. The notion of preservation of cultural heritage has been exercised for several years. With the advancement of digital technology, it has opened a new avenue for preserving the cultural heritage of a nation. Due to natural or man-made disasters, we see a loss of many historic buildings which are to be passed on to future generations. The digitization of these historical objects is very important to store these and prevent them from getting extinct. The digital preservation of various visual arts like paintings, sculptures, and ancient architectural buildings is the key technology till date to preserve the culture of a nation. This paper shows various methods of storing the historic objects by using scanners through the concept of reverse engineering. Using reverse engineering the shortcomings in the documentation can be improved.**

**The work is concerned with preserving the cultural heritage by making the digital copy of the object and to reuse the data, when needed. When there is a need of a particular model of the past they can be revived without any loss in their heritage. The main objective of this paper is to show how to use reverse engineering method to digitalize the characteristics of the old artifacts which are considered national treasure.**

**Index Terms— Reverse engineering, Cultural Heritage, Digital Preservation, CAD, CMM Scanner.**

## I. INTRODUCTION

Cultural heritage comprises of the physical artefacts as well as the intangible attributes that are passed down through generations. It also includes the tangible items like Monuments, Piece of Arts, Literature and also intangible items like Values, Traditions or belies etc. The efforts of protecting the cultural heritage for future generations is Known as Preservation. The digitalization of cultural heritage with help of scanners and R.E(reverse engineering) methodology has piqued the interest of many Archeologists because many important and old objects that have a great legacy can simply be destroyed like Various musical instruments of the past and monuments etc[1][20]. The digitization not only helps in preserving but can also be used to make digital copies and store the digital data at various locations at a very little cost which is not possible with the original. With the Advancements of the computer technologies, their applications can be used in virtualizing the cultural heritage not only to make digital copies of the models showing its shapes, texture and type of material used but also use the reverse engineering methodology to reconstruct the objects that have been lost. The process allows for the reconstructions and preservation of objects that are lost due to unexpected events. We also discuss various avenues to digital preservation of the cultural heritage.

Reverse Engineering also Known as back engineering is a process of acquiring knowledge of design information by examining a product. For example the dismantling an automobiles to study the various components and reproduce it based on the original model. Reverse Engineering can be used as tool which can preserve data by scanning the originals. Through literature study, it has been understood that R.E is applicable to many areas like Architecture, works of Art and old artefacts etc.[21][1][3]. In our engineering Industrial commercialized society, RE shows a lot of promise for application like mass production etc. 3-dimensional scanner is a device use to analysis real objects by collecting data on its appearance and shapes and use the data to construct a 3-D digital model.

## 2. PROBLEM IDENTIFICATION

The different objects of heritage value has been identified these pieces is not very big but are of traditional value some objects require to be preserved due to their heritage value and place value .Some objects are used for day to day activation but play an important role to be preserved. Some day objects as well as artefacts are known through ages. They can be flower vase, candle stands, aesthetic artefacts and some known vessels. Idols are of great importance and have different names in different area. Ganesh idols and Nataraj idols of various even can be random greed for restoration. Painting and carving can also be preserved in CAD data so as

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to conserve the traditional knowledge and area specific beauty.

Many renowned shrines which hold great traditional value were destroyed due to natural calamities for example Kedarnath shrine carving on the walls are destroyed due to the floods in 2013. Also the carving on the Taj Mahal and other famous monuments are also withered in time so it is required to preserve these design for future purpose and with the digital technologies, this has become simpler to do.

***Figure 1 wall carving on the inside of Taj Mahal (http://pathlessridden.com/2015/07/agra-and-the-taj-mahal/)***

***Figure 2: Destroyed carving on the wall of kedarnath temple(http://indianexpress.com/article/india/hc-directs-sits-to-revisit-kedarnath-and-trace-remains-of-the-ones-who-died-in-2013-kedarnath-deluge4991793/)***

## 3. CONCEPT OF REVERSE ENGINEERING

Engineering is a process of manufacturing, designing and assembling products. There are broadly classified into two types. Forward Engineering and Reverse Engineering. Forward engineering is a conventional method of moving from logical designs to the implementation of a system. In some situations there may be a part without any design details such as Art, Engineering Tools etc. Thus, the process of replicating an existing objects or parts without any drawings or engineering design data is known as reverse engineering. Reverse engineering can also be described as the process of generating a CAD model from cloud data points acquired by the use of scanners.

Reverse Engineering has a wide range of applications such as jewellery design, Industrial design. For example when a new product in launched on the market the competing manufacturing may get one and dismantle it to study how works and also learn the details of its construction.

### *3.1. The Reasons for using R.E are as follows*

1)When the customer need of a product for which the manufacturing no longer exists, e.g parts of an aircraft required mainly often air craft has been in service for long time.
2)The manufacturer doesn't produce the particular products e.g the original product becomes outdated.
3)The product design data has been lost or never existed.
4)To create data to renovate a part, if the CAD data of the particular part has been obsolete.
5)To analyze the pros & cons of competitor's product.
6)To make changes in the products like eliminating the bad features or enhancing the good features.
7)To explore new roads to refine performance of products and its characteristics.

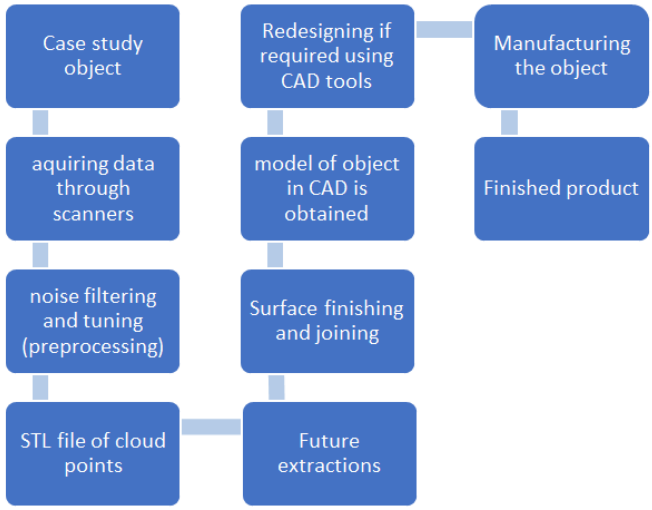


***Figure 3: Phases of Reverse Engineering***

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### 3.2. *Process of Reverse Engineering*

At first, the object required to be reverse engineering is to be selected, to either study how it works or to renovate some feature of a particular product. Next we use 3-D scanners to a quire the data and then the data is pre processed i.e. removing noise and avoid merging. The point cloud data in STL format is obtained. Now, the cloud data is joined and surface formed and the CAD model is obtained. Any design changes can be done using CAD software and the product can be manufactured and the desired product can be produced.

## 4. SCANNING DEVICES

Three dimensional scanners are used to scan the part, producing point cloud data that are used to define the surface geometry. These devices are present as additional tools to CNC machine. There are two types of scanners, contact type and non contact type.

### 4.1. *Contact Type Scanners*

They have contact probes that automatically move to every contours of a physical surface. At present, contact probe scanning devices are based on CMM technologies. They are having a tolerance range of +0.01 to 0.02 mm. These types of scanners may take time in scanning, depending on the size of the object because the probe has to move.

### 4.2. *Non Contact Type Scanners*

These types of scanners do not have any physical contact with the object .Generally, they use optics, lasers, charge-coupled device (CCD) sensors to capture point data. The main advantage of this type of scanner is it scans in less time. The tolerance limit is within ±0.025 to 0.2 mm.

### 4.3. *Coordinate Measuring Machine(CMM)*

Now-a-days, CMM (Coordinate Measuring Machine) are widely used in the manufacturing industry to illustrate 3-D sizes, shapes and, different types of machining tools. Due their high accuracy, high usability and, availability, their role in Reverse Engineering society is growing rapidly but they are not very user friendly as the results obtained may be difficult to understand. CMM are vital tool mainly in the automobile industry for developing new vehicles, examination of the machine parts and mouldings, safety as well as environmental tests.

A Coordinate Measuring Machine (CMM) (Fig- 4) is basically a very accurate Cartesian robot provided with a tactile probe and used as 3-D scanner. This probe under automated/manual control comes in contact with a sequence of points on the surface of the objects to be measured and the CMM generates set of x, y, z coordinates of these point contacts. The coordinate sets are deciphered by algorithms that support Reverse Engineering. CMM are not only used for scanning 3-D objects but can also be used as inspection tool to investigate the dimensions of the particular objects. CMM is not dependent on object, it can be used on wide range of objects. The operations of the CMM can be completely automated and the result can be converted into CAD model. CMM consists of mainly for components, they are, The Machine, Tactile Probe, The Computer System, The Computer Software.


***Figure 4: CMM machine GLOBAL 071007 at JHARKHAND tool room***

#### 4.3.1. *Specification of CMM and Measuring Conditions*

| | |
|---|---|
| **Model name** | GLOBAL performances 071007 |
| **Manufacturer** | Hexagon Metrology S.p.A., Grugilasco,(TO), ITALY |
| **Range of Measurement** | X – 700mm<br>Y – 1000mm<br>Z – 660mm |
| **work piece weight limit** | 1200Kg |
| **Accuracy** | 1.5+ L/333µm |
| **Temperature Range** | 16 – 26℃ |

***Table 1: Specifications of CMM and Measuring conditions***

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## 5. METHODOLOGY:

Two Objects were selected, a flower vase and a vessel which are very old artifacts. They were scanned using a CMM scanner GLOBAL--071007. The Cloud points of the above mentioned artifacts were generated. For getting the patch layout of the surface were considered and consequently the AutoCAD software is used. In order to create a surface through the cloud data points CATIA software is used and the rough and curved surfaces are taken care of. The collected data points are in "STL" format. The surfaces were created from point cloud command to create a surface from several point clouds. The areas the need to be included were only selected and other cloud points were filtered. This command was used to select entire point cloud or areas of point clouds to include in the surface.

### *5.1.Case Study:*

Two old flower vases were chosen to be digitalized for restoration and preservation. The two vase were taken to the JHARKHAND tool room and were scanned using a CMM scanner. The cloud point data generated is noisy, thus required pre-processing was done. After pre-processing the obtained cloud points were joined and converted into a mesh and then the surfaces were formed using CATIA software. The cloud points, wire frame and final digital copy of chosen flower vases are shown below:--

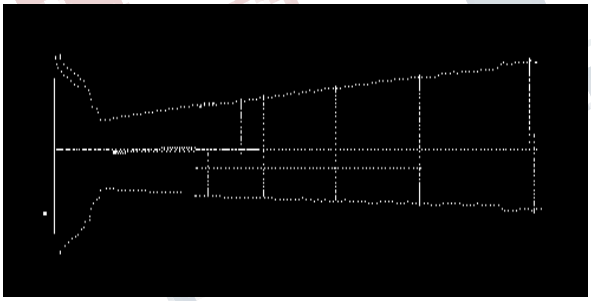

***Figure 5 : Cloud point data for Flower vase 1***

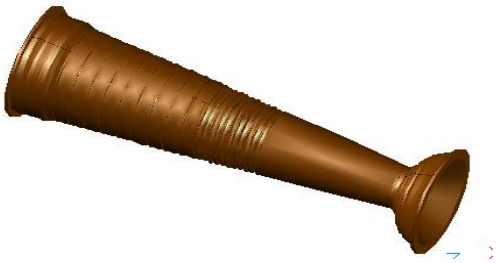

***Figure 6 : Digital copy of Flower vase 1***

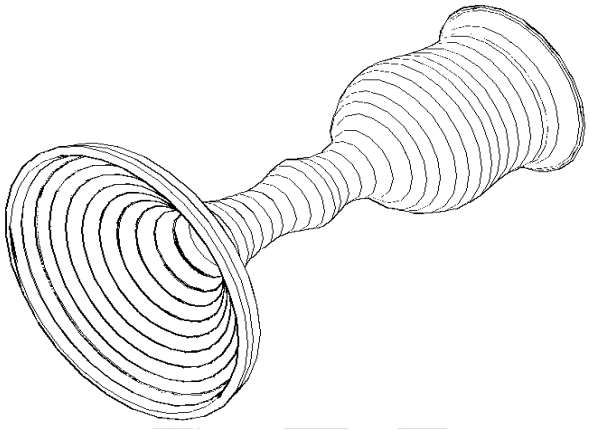

***Figure 7 : Wire frame and Digital copy of Flower vase 2***

## CONCLUSION

In this paper, the use of reverse engineering to preserve and restore old artifacts is reviewed for the protection of Cultural Heritage. One type of Method is explained. Two case studies were taken and their respective digital copies are generated by collecting data as cloud points in STL format using a CMM scanner and then the surface are formed using CATIA Software. 3-D digital copies are best suited for a clear and detailed measure of the present situations and these copies can be utilized in the future. By applying R.E methodology for reconstruction and replication and new products with enhanced features without losing its integrity of the past can be produced. The loss of monuments due to natural calamities can be reconstructed using this method and their beauty and legacy can be restored. This paper also helps to improve the awareness on the importance of the cultural heritage.

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## 6. REFERENCES

1.BAJIC, D[razen], CELENT, L[uka]& JOZIC, S[onja].(2011). Reverese Engineering Application in Preservation of Cultural Heritage.

2. Anderson, S. Curless, B. Davis, J.Fulk, D. Ginesberg, M. Levoy,M. Koller,D. Pereira,L.Pulli, K.Rusinkiewicz, S. Shade, J.(2000). The Digital Michelangelo Project 3d Scanning of Large Statues.Proc.siggraph .

3. Chen, Y.H. Ng, C. T.(1997). Integrated Reverse Engineering and Rapid Prototyping, Computers & Industrial engineering.

4. Cosma, C. Dume, A. Tulcan, A. Iclanzan, T. (25-28th November 2009). Rapid Development of Products using the Technique of Reverse Engineering, Annals of Daaam for 2009 & Proceedings of the 20th International Daaam Symposium.

5. Fassi, F. Fregonese, L. Brumana, R. Monti, C. Achilee, C. cassani, C. Vio, E. (06-October 2007), Anthens ,Greece(2007). High Density Digital form for Cultural Heritage , Synthetic Modeling and Reverse Engineering of the Four Horses of the Basilica of San marco in venice ,xxi international cipa symposium.

6. Hong-Tzong, Y.(1997). Reverse Engineering of the Engine Intake ports by Digitization and Surface Approximation , International Journal of Machine Tools and Manufacture , Elsevier Science ltd.

7. Rypl,D. Bittnar, Z.(2006). Generation of Computational Surface Meshes of stl Models, Journal of Computational and Applied Mathematics.

8. Sokovic, M. Kopac, J.(2006). R.E(reverse engineering) as Necessary Phase by Rapid Product Development, Jounnal of Materials Processing Technology.

9. Szilvasi - Nagy, M. & Matyasi, Gy, (2003). Analysis of STL files, Mathematical and Computer Modeling.

10. Colin Bradley and Bernadette Currie(2005). Advances in the field of Reverse Engineering. 11. C. Vilbrandt, G. Pasko, A. Pasko, P- A. Fayolle , T. Vibrandt, J. R. Goodwin, J.M. Goodwin and T.L. Kunii(2003). Cultural Heritage Preservation using Constructive Shape Modeling.

12. K wan, H.Lee, H.Woo(2000). Direct Intigration of Reverse Engineering and Rapid Prototyping.

13. Venkat Deepak Kolar (april,2004). Application of Reverse Engineering and Rapid Prototyping to Casting.

14. Nagozi Sherry Ali(MAY 2005). Reverse Engineering of Automotive parts Applying laser Scanning and Structured Light Techniques.

15. Suveg, I. Vosselman, G.(2000). 3D Reconstruction of Bond models.

16. G. Toz, Z. Duran(2001) . ocumentation and Analysis of Cultural Heritage by Photogrametric Methods and gis : A Case Study.

17. George Pavlidis, Despoina T siiafakis, Vassilions Tsioukas, AnesticKoutsoudies, Fotis Arnaoutoglou and Christodoulos Chamzas.(2007) Preservation of Architectural Heritage Through 3D Digitization.

18. Saptarshi Kolay.(2016). Cultural Heritage Preservation of Traditional Indian art through Virtual New- Media.

19. Mariana calin, George Damian,Tiberiu Popescu, Raluca Manea, Bogdan Erghelegiu, Tudor Salageon. (2015). 3-D Modeling for Digital Presrvation of Romanian Heritage Monuments .

20. Raynel Mendoza, Ramoz Fabregat, Silvia Baldiris. (2015). Fram Work to Heritage Education using Emerging Technology.

21. Pandey, R ., Pattanaik, L.N. and Kumar, S.,(2010). A Reverse Engineering based Process for Contextualizing and Digitizing IncidentTechnical objects.

22. Pandey, R. and Pattanaik, L. N.,(2014).A Fuzzy QFD Approach to Implement Reverse Engineering in Prosthetic Socket Development.

23. Pandey, R., Pattanaik, L. N., and Kumar, S.,(2015). A Fuzzy Linguistic Hedges in the Selection of Manufacturing Process for Prosthetic Sockets.