AUGMENTED REALITY APPLICATION – ANTIQUE OBJECT RESTORATION

VII SEMESTER - MINI PROJECT REPORT
FOR THE DEGREE OF

BACHELOR OF TECHNOLOGY
IN
INFORMATION TECHNOLOGY

BY

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UNDER THE SUPERVISION OF

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INDIAN INSTITUTE OF INFORMATION TECHNOLOGY,ALLAHABAD

19th November 2018

Candidate's Declaration

I hereby declare that the work presented in this project report entitled "**Augmented Reality Application – Antique Object Restoration"** submitted end-semester report of 7th Semester report of B.Tech. (IT) at Indian Institute of Information Technology, Allahabad, is an authenticated record of my original work carried out from July 2018 to November 2018 under the guidance of **Prof. Anupam Agrawal**. Due acknowledgements has been made in the text to all other material used. The project was done in full compliance with the requirements and constraints of the prescribed curriculum.

Place: IIIT Allahabad Tanishk Rana - IIT2015019

Date: 19-11-18

Supervisor's Certificate

I do hereby recommend that the mini project report prepared under my supervision by Tanishk Rana (IIT2015019) titled "**Augmented Reality Application – Antique Object Restoration**" be accepted in the fulfilment of the requirements of the completion of 7th semester of Bachelor of Technology in Information Technology for Examination.

Date: 19-11-2018 Prof. Anupam Agrawal

Place: Allahabad, IIIT Allahabad

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1. Abstract

Augmented Reality (AR) is a technology which produces a synthesis between a computer-generated data and the physical world of a viewer while establishing 3D registration as well as allowing real time interaction between the user and the objects which have been augmented into the 'virtual world'. In this paper, we apply this novel technology to 'reconstruct' antique objects that have sustained damaged in a way that users can see the object as a whole via a computer generated AR 3D Poly-model. It is another step in the domain of HCI [6] (Human Computer Interaction) as it involves active involvement of the user. Our application serves the purpose of object restoration utilizing the resources readily available to us in this day and age.

2. Introduction and Motivation

Augmented Reality is a powerful technology, with which developers can create virtually anything they design. The need for AR in an academic domain was ever present, since it can visually bring inanimate objects to life within the 3 dimensions, therefore it has great potential within this domain.

In this report, we explore the possibility of AR in the domain of **Object restoration**, specifically that of some antique objects, and to create a digital and interactive experience for the user. Augmented Reality plays a vital role since we plan to augment models of ancient objects, which may or may not be intact, onto a target, so that users may get a more interactive learning experience, wherein they can digitally manipulate the object and view it as a whole.

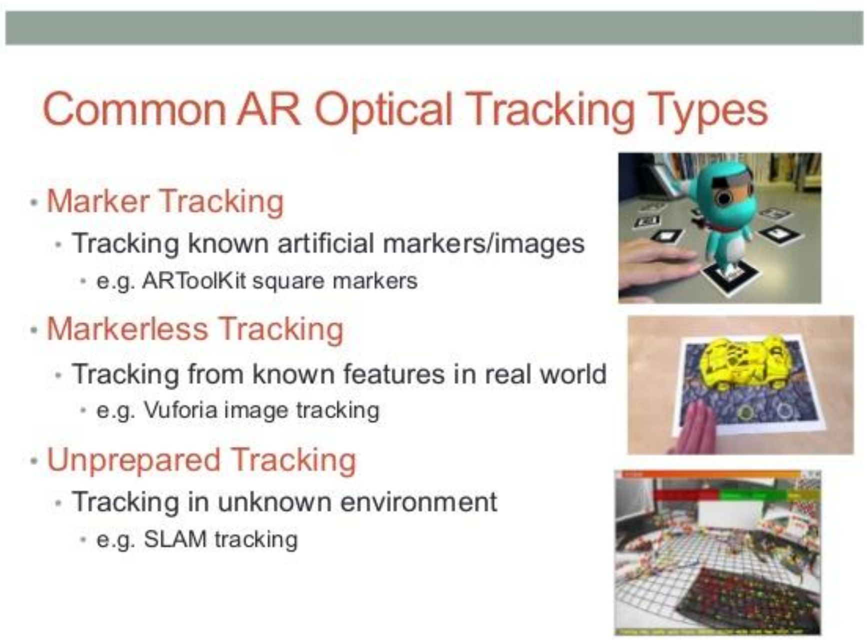

Fig 1. Types of AR tracking methods

Marker Based:

In a **marker-based AR** application, the images (or the corresponding image descriptors) to be recognized **are provided beforehand**. In this case you know *exactly* what the application will search for while acquiring camera data (camera frames). High accuracy can be obtained by using marker-based AR applications since the marker serves as a platform any model augmentation, such as in our case, which can then be subject to digital manipulation by the user.

Marker Less:

In a **marker-less AR** application, the app recognizes *things* that were not directly provided to the application beforehand. This scenario is much more difficult to implement because the recognition algorithm running in the AR application has to identify patterns, colors or some other features that may exist in camera frames. This process bears a high cost of computation an may affect performance since there is a perpetual background process working to identify potential patterns.

The application serves to augment a 3D model of the intact object, which is generated from existing pictures of the object, in such a way that users can visually see the damaged object in the real world 'reconstructed' via the augmented model. The users can manipulate the 3D model as they see fit, using various touch/ finger gestures and understand the overall structure of a host of antique objects in this manner.

3. Problem definition and Objectives

The problem at hand is to use features of Augmented Reality in the form of a handheld application, i.e. Android OS/ iOS to create and augment a 3D model in the user's device when viewing **antique objects**, which may have sustained some physical damage over time, in an attempt to recreate them virtually.

Fig 2. Restoration of an object using an marker based - AR 3D model.

The above figure, **Fig 2**, accurately depicts what we aim to achieve. Through AR, the aim was to successfully recreate the whole object and view it, using the augmented model, as it would have been had it not sustained any physical damage.

Essentially, this process serves as a method for digital restoration, since we can view the entire object using AR technology. Consequently, the next step would be to create 3D models of objects which can be augmented onto a devices, and this has been done using special open source softwares which can create a satisfactory 3D model of any object that can be manipulated by the user, which is done by using a dataset of various images of the intact object.

Once the model is rendered and augmented onto the users device, he/ she will be able to interact with it and understand the complete architecture of the object.

Objectives

1. Prepare an application to augment 3D models of any object onto the artefact itself, complete with active participation of the user to manipulate the 3D model and see the 'restored' object and understand its physical characteristics.

2. Prepare a 3D model of an existing object solely from its images and use this model to 'reconstruct' the damaged object.

3. Registration and tracking for AR visualization. To ensure satisfactory visual restoration, the user is given freedom to manipulate the 3D Model using Touch/ gestures so he/ she can see the restored object as well as the damaged artefact.

4. Port onto iOS platform to provide multi-platform service.

4. Challenges

The major challenges faced during the development of this application were visually satisfactory restoration using the models, and allowing the user to manipulate the models, which involved taking touch/ gestures as input.

- As described above, the primary challenge faced was availability and designing of the 3D models. To create completely intact models of the damaged objects, we have used a set of images of the intact object, and used this model within the mobile application along with AR. The model also needs to be lightweight, so only certain high level texture features were maintained during final conversion, to focus on the edges (skeleton).

- Another key challenge faced was including the touch/ gesture input to allow users to digitally manipulate the 3D models as they see fit, to allow them to understand the architecture of the intact object. Scripts coded in C# were created to allow the functionality of translation, scale modification and rotation of the model through the user's touch/ gestures input. Unity allows custom packages to be imported, so the addition of this functionality into the application was simplified. These features were necessary for the user to digitally interact with the models, and to compare the 3D model with the damaged object, and see the scope for restoration via AR.

5. Literature Review

The following research papers were reviewed based on latest Augmented Reality techniques using 2D and 3D poly models for object augmenting, modelling and restoration. Each paper marked a new and different avenue for AR, be it science, industry, marketing, or just basic applications to better human life.

The following table summarizes the insights gained by concisely listing the merits demerits of all methods used.

Sr.No	Title	Publication	Methodology	Datasets	Merits & Demerits	Future Scope
1.	A Stable and Accurate Marker-Less Augmented Reality Registration Method	2017 International Conference on Cyberworlds (CW) - **IEEE**	Designed a novel approach for AR registration using 3 different matrices, Transformation , Projection and ModelView matrix in OpenGL.	Private office image dataset.	**Merits:** Improved virtual registration and solved flickering problem in VR, thereby increasing overall efficiency of AR systems to come.	This paper contributed to the marker less sector of AR in a huge way, impacting many major fields in AR.
2.	Real-time Augmented Reality shopping platform for studying consumer cognitive experiences.	2013 2nd Experiment International Conference - **IEEE**	Using marker-based and non-marker-based approaches using Microsoft Kinect and Unity3D.	Private SQLite dataset	**Merits:** Correctly analyse the trends in the AR and VR, and draw a comparison chart. **Demerits:** Difficult to port onto widespread platforms, and	Demo application can be used in retail as is being done in various companies like Lenskart.

					requires extensive hardware.	
Sr.No	**Title**	**Publication**	**Methodology**	**Datasets**	**Merits & Demerits**	**Future Scope**
3.	Mark less augmented reality registration algorithm based on ORB	2014 12th International Conference on Signal Processing (ICSP) - **IEEE**	Improved existing ORB Algorithm in Mark less Augmented Reality registration and tracking	Ground Truth Dataset	**Merits:** Compared merits of ORB algorithm to existing tracking algorithms, and proved that ORB is better choice. **Demerits:** Merely a comparison between existing algorithms. Could be extended further.	This paper has the potential to further research ORB algorithm, and seek new methods to increase efficiency.
4.	Introduction to AR - Aeronautical Maintenance	2011 13th International Conference on Transparent Optical Networks - **IEEE**	Explores feasibility of AR in industry with the help of HMDs and future potential.	Aeronautical Maintenance Model.	**Merits:** Discusses the potential and feasibility of AR systems to replace complex HW system. **Demerits:** Result is subjective, as it pertains to a very specific industry field.	The paper's main objective is to extrapolate current progress in AR and discuss how it may replace traditional systems.
5.	User Trends in AR and VR.	2012 International Symposium on	Compare the trends and progress of AR vs VR by	Usergroup based.	**Merits:** Correctly analyse the trends in	Collect more data and improve accuracy of

		Ubiquitous Virtual Reality - **IEEE**	calculating papers published and citations.		the AR and VR, and draw a comparison chart. **Demerits:** Since research is user group based, it may be biased in some aspects.	findings.

Sr.No	Title	Publication	Methodology	Datasets	Merits & Demerits	Future Scope
6.	Human Computer Interaction Augmented Reality	International Journal of Engineering Science and Computing, August 2016 - **IJESC**	Analysis and case study of popular AR projects. Exploring use of AR in devices, headsets.		**Merits:** Explores the growing trend of involving AR in mobile applications, and its impact on the digital market scenario. **Demerits:** No original research. Case study on existing AR projects, case in point 'Pokemon Go'.	Understanding HCI even further and working towards introducing an interactive environment for the user.
7.	Major advances in Augmented Reality	Computers & Graphics, November 2001 - **IEEE**	Explored recent advances in AR, and compared the efficiency of HMDs vs LCD panels, and prepared a custom AR - VGA combination and SCAAT	Numerous private datasets.	**Merits:** Efficiently explored various AR devices and correctly drew up pros and cons of each, both HMDs and Panels,	Since the paper was published in 2001, we can actually see the future scope in the present, since AR industry is generating ~ $15 billion in revenue alone.

			(Single Constraint at a time) algorithm.		and outdoor and indoor AR environments. **Demerits:** Required extensive HW apparatus, including HMDs and several expensive devices to simulate real world environment.	

6. Methodology and Implementation

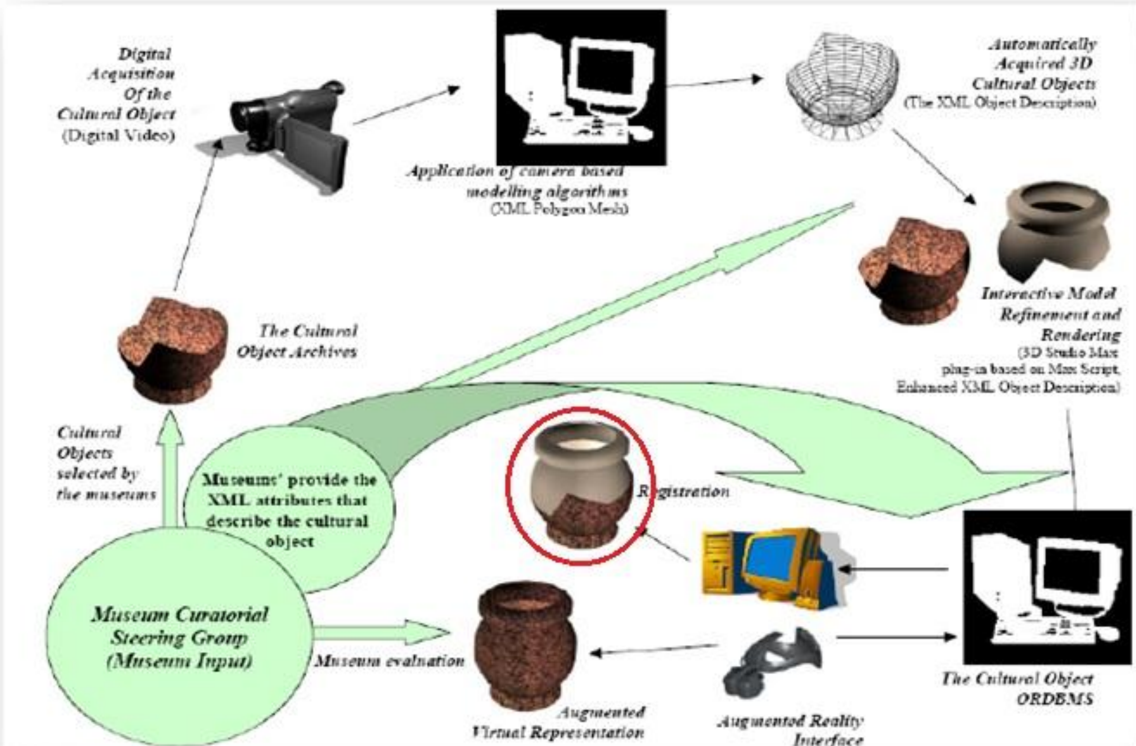

Fig 3. Diagrammatic flow-chart of the application's working.

For any object which has sustained physical damage through time or human error, we can design a 3D model using its pictures. This 3D model can then be augmented onto the existing and incomplete object and can be viewed as a whole. Essentially, the application projects the model using the object's image target, a unique target for that matter, which the user can then manipulate using touch and gesture input . To view the restored section, the user can allow the model to sit onto the damaged artefact, and compare the results.

The primary feature for satisfactory model augmentation is **Registration and Tracking**, which describes how the system tracks the location of the image target and decides to augment the model onto it. It takes into account the distance from the source, orientation of the object with respect to the source and projects the model onto the target. By adding the user input functionality, our application now follows registration and tracking in the physical space even after being manipulated by the user with respect to its position, size or orientation.

Implementation and Tools used:

The following softwares were used extensively for the development of the application:

- **Unity 3D Engine** - Primary software for creation of AR application and allowing implementation of user touch/ gesture functionality via **LeanTouch**.
- **Regard3D** and **Blender-** Used to generate 3D model of an object using high resolution images which is then ported onto Unity.
- **Vuforia** - Developer platform working alongside Unity for designing the AR section and deciding strength of image targets.
- **ARCore** - Open source software by Google to prepare mobile applications which use AR.
- **XCode** - Inbuilt within Unity to port onto iOS application.

3D Model Generation:

The first step was to prepare a 3D model of an existing object from its images using Regard3D, which could then be used for augmentation. The processes followed, in order, were Matching, Triangulation, Densification and Surface Generation using the CMVS/ PMVS method with incremental approach.

Fig 4. Actual image v/s 3D generated Poly-model

As seen in **Fig 4,** we have a direct comparison of the actual object and its 3D model, generated using Regard3D. The generation is a highly complex procedure, and the model thus formed is extremely heavy in terms of size, so to feasibly use it in our application, it was simplified by dropping some visual attributes and textures when porting it to Unity for usage.

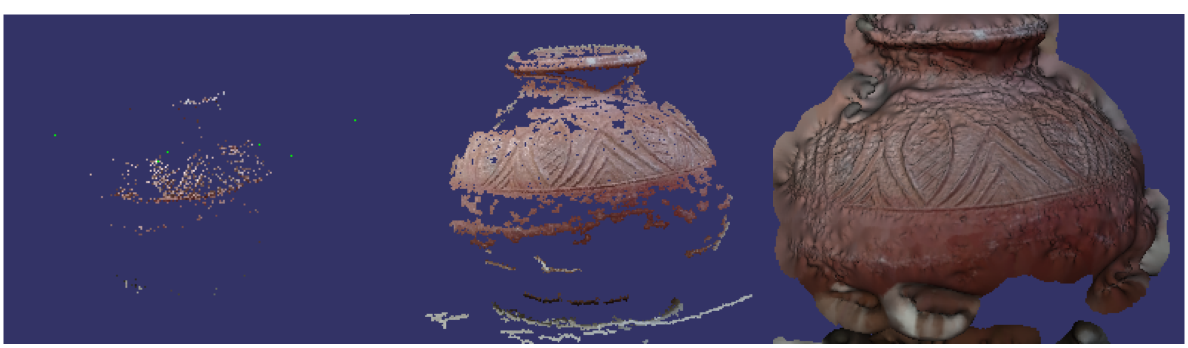

Fig 5. (a)Incremental Triangulation (b) CMVS/ PMVS Densification (c) Surface Generation

Fig 5 captures the process of model creation Regard3D. The image set used consisted of 18 images, and the technique used was CMVS/ PMVS along with

Incremental triangulation, which is recommended for small data set sizes and for single objects, such as ours. The final result had some noise around the base and edges, and was extremely heavy to use in a mobile application, so while porting it onto Unity, only the finer details were maintained along with the shape of the object.

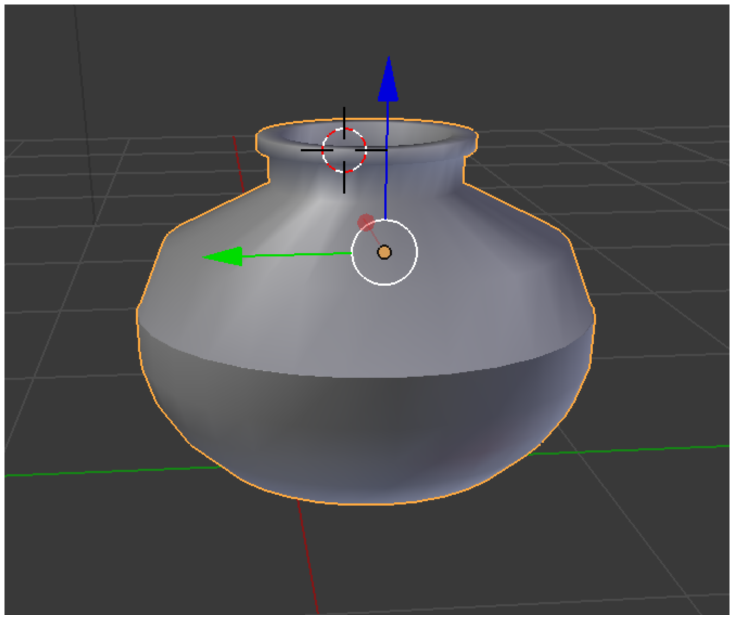

Fig 6. Shape in Blender

The above image shows how the shape of the model was created in Blender, which could take on the texture from our generated surface. This model can directly be used in our application now.

Unity Application:

Within Unity itself, the application was designed in such a way that it could work for a total of 4 models thus far, including our custom 3D model and standard models as well. Since we required the application to be extremely efficient and lightweight, our custom model had to be stripped down to just include the high level features while maintaining the skeletal integrity of the object. The augmented models had to be given certain prerequisite attributes, which are encompassed in the transform matrix, mentioned below.

Transform Matrix: 3x3 matrix consisting of real values, each row for position, rotation and scale of the model in the physical space, as seen in **Fig 6.**

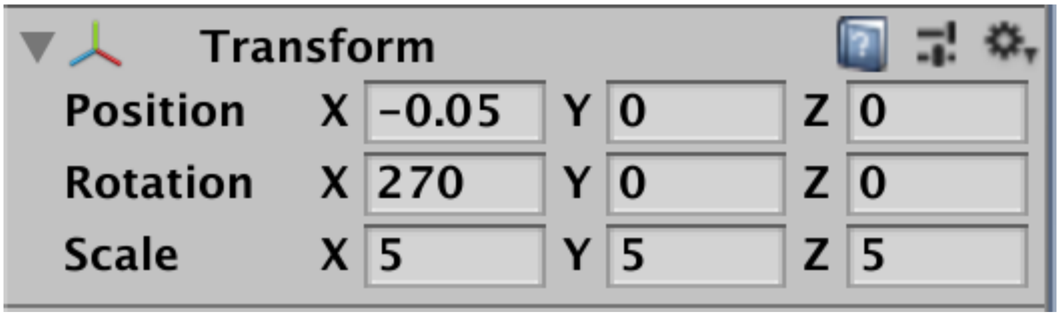

Fig 7. Transform matrix of Model 2 in the application

LeanTouch Components (For User manipulation) : Unity allows developers to import custom packages to provide additional functionality, which was necessary in our case since we wanted users to be able to interact with the 3D models. Scripts added to each Quad component were:

- **Lean Translate:** This allows the user to move the object within the device frame using his touch input. It works by calculating the point of origin of touch and traces the path taken and moves the model accordingly. This is crucial for the user if he wants to shift the model exactly onto the artefact.
- **Lean Scale:** This script allows the user to enforce pinch-zoom and modify the size of the model. Directly linked to the Scale row in the transform matrix, this is an essential component to allow the user to manipulate the model.
- **Lean Rotate:** This is primarily concerned with the orientation of the model with respect to the Z - axis of the plane of the physical space. Using basic gestures, the user can rotate the model and view it from multiple angles.

7. Results

Fig 8. Screenshot of the application - Model v/s object

As seen above in **Fig 8**, our application can successfully augment the model, which is visually comparable to the existing object without any glitches. This is complete with the user's ability to move, scale and rotate the object on its axis so he/ she can understand the architecture of the object and see the missing/ broken parts if any. The features extracted from the object were the pattern around the center and the overall hue of the object. After surface generation, the model had to be simplified in order to be used within the application, therefore it differs slightly from its version after Poisson surface generation in Regard3D. Our application can augment other models as well, along with the same features, but our focus was to use our own model which was created solely by its images, to prove that it can be done with other objects and artefacts as well.

8. Conclusion

This paper presents a successfully application of AR within an academic domain using custom models. The fact that we can satisfactorily create a 3D model out of images of any object is a great step towards completely seamless digital object restoration. The CMVS/ PMVS method of Surface generation was explored since our model was of a singular object within a small scene, and the results were brilliant, especially with respect to the shape and texture of the object. Such applications may find great utility within a museum environment for example, where users can actually see and comprehend for themselves the design and architecture of these damaged objects. Further progress can be made in this field, to include more number of models and to add other user functionalities.

10. References

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Suggestions by the Board Members