Paleontology In VFX

Abstract

This PDF is a condensed overview of the following articles:

- A Continuation on Paleontology in VFX
- Where Archaeology Meets VFX

- In this article we are going to talk about how the world of CGI is being implemented in Paleontology and Archaeology. In cultural and historical fields, it is incredibly important to show where we came from, and the creatures that existed before us. So let's get started into how visual effects are being used as a preservation tool for scientists.

3-D Reconstructions

3D reconstructions are a huge part of modern day Paleontology. By reconstructing a fossil or creature in a 3D environment we can explore it in a less invasive way than if we were to pick it off the ground and open it up. This technique can also help us to explore the anatomy, development, and preservation of fossils. We can also test hypotheses on 3D reconstructions rather than destroying something in its natural state.

These techniques are being used on fossils, as well as some others. One of them being Tomography.

Tomography makes it possible to image a series of 2D sections or slices through a fossil with X-rays, and to use them to make a 3D reconstruction of a specimen. Through this technique, numerous fossils have been able to be preserved and digitally characterized so they can be safely analysed.

Tomography also allows for large 3D digital datasets to be shared and collected. This provides a solution to a long time issue of access to rare fossil material. Another problem Tomography solves is how to extract fossils safely from their host rock. The conventional approach is to physically remove the rock from the fossil using either a mechanical method, or stripping away the enclosing material using drilling tools. This often causes damage to the specimens, and is risky to the preservation process. For instance, traditional excavation can damage delicate structures, preserved soft tissues and other exposed bones or shells. By scanning the objects into a 3D environment there is now no need to risk damaging or cutting up an object physically to solve a hypothesis.

Tomography is not a recent innovation in paleontology. Its roots can be traced to the early twentieth century, where a scientist by the name of William Sollas began the task of manually grinding away fossils embedded in rock. Then he would photograph or trace by hand the exposed surfaces. However, it won't be long until X-rays would start to replace this method, as they were seen as a fast way of imaging a fossil. In 1895, paleontologists had begun using X-rays to examine difficult-to-prepare material.

A few other imaging techniques being used on fossils are FIB tomography, Micro-CT, Synchrotron-based tomography, Neutron tomography, Magnetic resonance imaging (MRI), and Laser scanning.

Educational Visualization Tools

It's fair to say one of the most important aspects of Paleontology is teaching others about the discovered information. So let's talk about how Paleontology is being taught, and how the world of CGI is pushing that along.

There are a few different questions that need to be thought about when teachers use scientific visualizations in the classroom. Some of them are key for getting students to focus and understand what is going on.

- What do students focus on in a visualization?
- How does the visualization promote generation of new questions?
- How do students understand and interpret the processes that are represented?
- What are you trying to teach? What do you want the students to learn?

So keeping these questions in mind, it is important for teachers and visualizers to form simulations and ideas around these topics. Otherwise, information will be missed, and people won't learn anything from the visual data. Keeping that also in mind, let's now discuss some other forms of media that Paleontology data is being taught in.

Interactive models or animations, are some of the most interesting tools to use in a classroom or museum. However, it is almost impossible to format them into scientific publications. The only current way is to use 3-D PDF technology to enable direct interaction with the digital objects. These were originally developed to present 3-D data in the manufacturing, engineering and architecture industries, But they are now also slowly finding their way into scientific publications. The 3-D objects can be rotated, translated, and scaled and take in accurate measurements of digital models. These allow for students to study and manipulate a range of fossil specimens, and also interpret external and internal details.

QR codes are also being used in museums to store information in plain text or URL addresses. QR codes are perfect for creating access to quick and easy to understand information.

Photogrammetry and 3D Modeling In Archaeology

Archaeology is the study of human activity through the recovery and analysis of ancient cultural materials. It is a sub-study of paleontology. Some of the greatest recorded studies of archaeology are from Ancient Egypt, Mesopotamia, and European culture. Archaeology is both a social science and a branch of the humanities. It studies everything from ancient artifacts, architecture, preserved bio-material, and cultural landscapes. It is a great way of understanding the past, explaining how our ancestors lived, and how technology developed.

One of the more recent developments of the 20th Century is that Archaeologists have been working hand in hand with computers to model what they find, restore, and showcase. I'm sure everyone of you at some point has seen a show from the early 2000s on the History or Discovery Channel. In those shows you often see 3D representations of the inside of the pyramids, structures, and other objects. Well scientists create 3D models for finds for more than just the Discovery Channel.

Excavation will always be the main source for any starting point in Archaeology. But afterwards it is important to preserve the dig site, and make sure it is easy to have continued access to discovered material. This can be a bit tricky if you wanted to continuously visit a site halfway around the world in person. However, if you introduce photogrammetry into this step everything becomes much easier.

Photogrammetry is the process of creating 3D scans by using both traditional photography and 3D models. Photogrammetry cameras can survey and map distances between objects. They can also capture color information, and geometry of objects. This information can then be entered into a 3D software. The software then decodes the information the camera has captured, and generates models from the selected measurements. After it is entered into a computer it can be used for GIS applications, cultural heritage documentation, and visual effects production.

3D models are important because they document objects and events like illustration or photography. This helps improve visualization of archaeological data for archival preservation and access. This also improves the research potential of any archaeology study by preserving more detail about the material, and allowing broader access to the study. It is generally easier to learn from something with pictures and realistic scale than just reading a textbook.

Cameras can also capture more light than we can naturally observe. So any scans of a dig or artifact can contain infrared data or other forms of indirect light. This can help archaeologists see remains of faded paintings, biological debris, or other objects. Photogrammetry can also preserve objects that cannot survive in their existing condition. This is incredibly helpful for documenting mummies or human remains, as they might start to degrade once they are exposed to direct sunlight and weather.

During these Covid ridden times, photogrammetry has become more important than ever. Since large groups of people, and traveling is not allowed, it is even harder to try and preserve artifacts. Some scientists have started combining photogrammetry with drones and LiDAR data, to explore terrain without leaving their homes. A U.K.-based archaeology team has continued their research

through the pandemic by using airborne survey data. They then analysed thousands of images derived from the drone's LiDAR data, and made high-resolution maps. So far they have found over 30 prehistoric Roman settlement enclosures, 20 prehistoric burial mounds, remains of hundreds of medieval farms, and a few quarries in the UK landscape. The study team was led by Dr. Chris Smart from the University of Exeter.

MayaArch3D

This collaborative internet project researches innovative approaches to integrate 3D digital models, and virtual reality environments online for teaching and research on ancient architecture and landscapes. Currently, You can go to the website and view 3D models of artifacts found at different dig sites, and virtual tours of them as well. It has grown into an international project that brings together art historians, archaeologists, and other cultural experts. As well as a group of specialists in remote sensing, photogrammetry, 3D modeling, and virtual reality. The MayaArch3D is overseen by The German Archaeological Institute (DAI) and the GIScience Research Group at the University of Heidelberg.

The Murale Project

The Murale Project is an Information Society and Technology project funded by the European Commission to advance the use of computer technology in archaeology. The Murale group is mainly formed by these groups: Brunel university in the UK, ETH University in Zurich, Switzerland, Eyetronics (Belgium), Imagination (Austria), the Technical University of Vienna (Austria), the University of Graz(Austria), and the University of Leuven (Belgium).

Their main "dig" or research site is located in Sagalassos, Turkey. They seek to develop and provide better tools that archaeologists themselves can use in situations. They also wish to develop easy-use tools that are adverse to elements (sun heat, dust, moisture), generate 3D models of objects at different scales, and create a faster and flexible approach to recovering materials.

They also are in the process of creating a public database for curating images of how a dig site and remains would look over time.

Virtual Reality Visualizations

As of 2017, The University of South Florida’s Center for Visualization & Applied Spatial Technologies and Integrative Biology departments are bringing dinosaurs to life in VR. A Biology professor named Ryan Carney, is using the technology to create interactive holographic images of dinosaurs. He wants to explain and better understand the origins of flight, and the connection of prehistoric fossils

to modern flying species. Dr. Carney is using a combination of X-ray, lasers, and computer animation to generate the 3D images of the fossils in virtual and augmented reality. He is one of the first scientists to fully integrate VR in their work, and hopes to see the potential for virtual reality as a tool for scientific research grow over the years.

Around about the same time in 2016, another scientist; Carlos Ginés Vázquez, set out to create a worldwide Fossil VR Database. This database is a collection of artifacts that have been scanned into the app and recreated in 3D for users to examine in detail. It includes small fossils trapped in sedimentary rock,skulls and other bones of dinosaurs. The Fossil VR Database is still in an early release version, but so far is doing fairly well.

The ARCHAVE System is a virtual system that is aimed at creating an immersive virtual reality environment for archaeological research. It started development in November 1999, and has grown since then. It's goal is to evaluate virtual reality interaction and data visualization techniques for scientific applications. So far they have worked with data from Brown University's Great Temple excavations in Petra, Jordan and many other University funded digs.

So far they have created a VR system that allows users to walk around dig sites, explore artifacts, and view other data separately or in large scale structures. The system is also allowing archaeologists to preserve and visualize the data they collect in a 3D environment. As well as enabling them to better understand the context of the excavation data, and gain freedom of movement through the datasets.

This entire system is answering the most basic question of Archaeology: What context is necessary for performing archaeological tasks?

The Current Evolution of Computational Paleontology

As technology evolves, so will the preservation techniques in Paleontology. Here are a few imaging sciences to look out for in the future, as well as some that are being developed right now.

In the last three decades, CT scanning and related imaging techniques (like neutron scanning) have opened up doors for investigations of fossil structures. Initially these studies were conducted on medical CT units, but now we can use micro and nano-level imaging to see inside fossils.

As we've seen media and Paleontology go hand in hand. Dinosaurs are still one of the most important and popular topics to cover in the media. However, there are more topics to Paleontology than just dinosaurs. A lot of the study depends on the scientific literacy of the public, so it's highly important we continue to develop new ways of teaching. The best way to do this fast, is through TV or streaming based programs, but it's not a topic that platforms sell well. So hardly any content is created. This is definitely something that needs to change.

Finally, a topic that we might see happen in the future is the development of Deep Time Earth Life Observatories (DETELOs). These are programs that would allow focused efforts by teams of

scientists to increase the pace of Paleontology research quickly and effectively. These teams would be a group of 10-20 paleontologists, geochemists, stratigraphers, geochronologists, paleoclimatologists, modelers and other geoscientists. By creating a unique team of researchers this would allow a unique perspective into how our Earth existed thousands of years ago, and how it will look going forward.

Visual Effects, Paleontology, and Cinematic Visualization

SciVfx is a Cinematic Scientific Visualization site that provides diagrams, abstractions and visual references for 3D artists to link science back into their work. It is overseen by artist Greg Barta from the United Kingdom. He aims to create a database of accessible forms of science communication, and visuals for photo-real CG and science based visual effects. Currently, there are some open access tutorials and reference material on the site, but Greg has stated that the content will expand into larger categories of science as time progresses.

So while researching this topic I was hoping to find VFX topics about how in the world of CGI movies were taking 3D scans and implementing them to improve backgrounds, matte paintings, etc. Or maybe something that would show how we are trying to teach history through the sets of Marvel movies. Sadly, I couldn't find anything. The majority of information I could find regarding Archaeology in Hollywood mostly had to do with Indiana Jones or The Mummy franchise. Which were less factual articles, and more trivia on the films. That being said, I think there is a ton of potential for movie makers to use Lidar scans, photogrammetry, and other documentation forms into films. We just need the right people to implement them.

However, I did find one person who is probably the best person in Toronto, or even Canada to talk about the integration of VFX and Archaeology. What he is creating is fantastic, and I did want to give him credit where credit is due.

Dr. Micheal Carter is a professor at The University of Ryerson. He is currently their Director Of Industry Relations, and leader in their Digital Media Program. Originally a technical director and producer in the VFX industry, and Senior Demo Artist at SideFX, he has a hugely rich background in visual effects and production. His research focuses on Artificial Intelligence (AI) and Culture, and he holds a PhD in Anthropology (Archaeology) from Western University. As well as various other degrees. He also ruins the website Theskonkworks, which beautifully showcases his work that he is doing with Animation and VFX for Heritage Visualization.

On his site you can see the restorations and models he is creating with VFX software. Such as Longhouses. These are a huge part of Canadian history. His longhouse models combine cultural interpretations of what they would have looked and felt like within the 16th century in Southwestern Ontario. Some of his longhouses are also open source resource tools for the public to use, and are combined projects with the Archaeological Services Inc., Sustainable Archaeology, Museum of Ontario Archaeology, and the University of Western Ontario.