CHAPTER 3

Animating Past Worlds

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Abstract

Creating 'past worlds' is more than just creative flair or technical wizardry, it is the distillation of grounded heritage interpretation and reflection as applied to the creative (re)visualization of ancient peoples and landscapes. Be it the digital dinosaurs of Jurassic Park or the fake placement of lifelike digital actors seamlessly inserted within media, virtual heritage is increasingly caught between the praxis of the visual enchantment of feature film and television visual effects (VFX), the increasing visual and phenomenological immersive worlds of 3D, virtual games and the hyper-reality of deep fake VFX. This chapter will provide the basics of animation, while at the same time introducing the reader to the concepts of virtual archaeology and digital cultural heritage from a digital visualization perspective.

Introduction

The concept of animation has been around for centuries and archaeologically, I would argue, reaches further back into hominid evolution. The walls of

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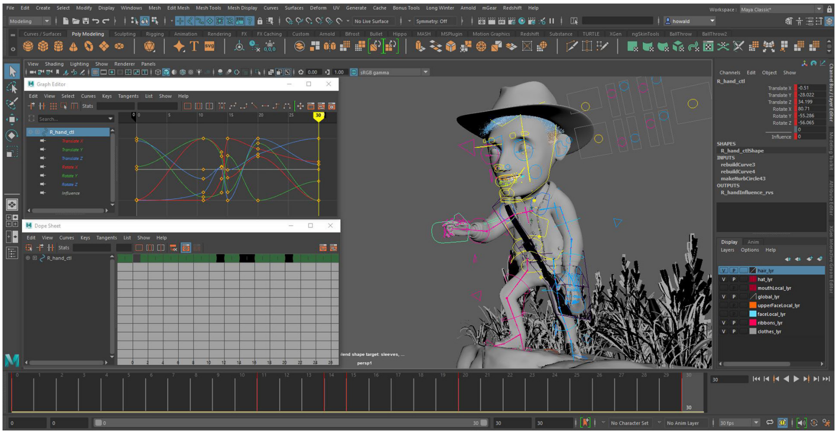

Figure 6: Adventure Man (2020) by Prof. Kris Howald, Sheridan College Computer Animation Program – Example of Animated Keyframes in Autodesk Maya.

Chauvet Caves, with their 37,000-year-old brilliantly sketched and painted depictions of hunting, prehistoric animals, and mythical creatures, dance when lit by fire or torchlight, as if animated in real time (see Azéma & Rivère 2012). Historically, the zoetrope, referred to as the 'wheel of life' is probably the most iconic tool or projector of animated images (Krasner 2013: 3). Invented by William George Horner in 1834, it included a cylinder with vertical slits on a base that allowed the cylinder to spin. When the cylinder was spun and the viewer looked through the slits to see a sequence of still images, animation could be perceived due to the rate of speed and the viewing angle.

However, it was the ground-breaking work of Victorian era photographer Eadweard Muybridge, who invented photographic technology to capture the movement of humans and animals, that formed the basis of animated film (see Baker 2007; Fresko 2013) working in Leipzig who made the next major contribution based on very simple measurements. In 1912, Windsor McCay took the concept of animated film and created one of the first animated shorts, Gertie the Dinosaur, inventing the use of keyframe animation and registration marks, which truly launched the artistic and technical process of animating images or objects (see Callahan 1988).

Today, there is an unprecedented use of animation, not only in entertainment but also in advertising, scientific visualization, and political propaganda. Animation is a convincing means to visualize imaginary characters, worlds, and concepts; combined with hyper-real image-rendering techniques, it can compel the viewer's mind to think that what is being seen could in fact be real. Although this chapter will not unpack the very real concern of how animation is now being used to promote alternative truths (see Westerlund 2019), it is important for us, as digital cultural heritage (DCH) practitioners, to reflect on how our unconscious biases influence the animated images we create and how those images also greatly influence how audiences engage with the virtual ancient cultural heritage worlds we illuminate.

We will explore the basics of 'animation' per se and how certain techniques can be used to enhance your digital cultural heritage research and potential skill-set. Given the huge range of animation techniques in various forms, such as 2D, 3D, real-time and stop-motion, I will focus on the use of 3D in film, virtual reality, and interactive gaming, which has recently exploded into the academic realm of digital cultural heritage.

What Is Animation?

The concept and word *animate* or *animato* comes from the ancient Latin meaning 'to give life' (Lewis & Short 1879). The current industry term *animation* also refers collectively to the creative and technical process in which to animate, whether it be 2D, 3D, or gaming environments. Animation comes in many forms: the traditional 2D sequenced images from Warner Bros. classics such as *Bugs Bunny*, computer-generated 3D worlds such as Pixar's *Toy Story*, or physical stop-motion such as Aardman's *Wallace & Gromit*. Visual Effects (VFX) is the seamless use of animation techniques integrated within live action film, such as *Jurassic Park* or *Lord of the Rings* franchises and in almost every TV show on air today. Animation drives 3D and 2D hand-held, console, and virtual games, now immersing the player into a new interactive experience.

In essence, to *animate* is to bring something imaginary/constructed/unreal to life. That something could be a wacky cartoon character, a loveable photorealistic Baby Yoda, or a perfect digital representation of a dead actor. All are artistic models built by creative and technical artists trained to visualize and interpret written descriptions, reference images, real objects, or environments. These models are inanimate objects that when created and animated are imbued with the style and techniques of their creators and as such, are enculturated, which is the conscious or unconscious imprinting of personal values and norms on digital data. As such, we must recognize the duty of care when bringing our vision of the past to life.

For each platform, animation takes on a different technique, however; all require objects, whether 2D, digital 3D, or physical to be moved by 'keyframes', which represents slices of motion in time. All action within the object itself, no matter how large or small, must be keyframed or 'keyed' on a per-frame basis in order for that object to be animated when sequenced together. In general, objects are animated by frames-per-second (fps). In film, the basis of all animation is 24fps. If the style of the animation is choppier, it is animated at 12fps.

For gaming, film or virtual reality (VR) that requires highly detailed or interactive movement, 48fps or higher is desirable. Why is this important? The higher the fps the more life-like or interactive the object appears to be.

Motion capture is like animation, in a sense that it attempts to record the life-like movement of real people, animals, and objects. Like Golem in the *Lord of the Rings* feature film series, the character on film was a 3D object, animated by a base layer of captured movement from a real-life actor. That motion data is recorded in real time by hundreds of sensors and cameras within a physical space when the performer is acting, then combined with a 3D character object in virtual space.

The Illusion of Life

Animation

To illuminate life is to mimic it. Several animation techniques are used to serve this process. They include primary, secondary, and tertiary movement, squash and stretch as well as over-exaggeration (see Thomas & Johnston 1995). Each technique is deployed at various intensities in order to trick the eye into believing it is a real-life character or to enhance the unbelievability of cartoon characters as they distort themselves into and out of situations.

Primary animation is the main movement of any object or character within 2D, 3D, gaming, or virtual space. It can be a simple as a walk cycle or moving from one side of the screen to another. Secondary animation is the movement that is affected by the primary movement of the object. On a virtual human that could be the sway of clothing or hair. Tertiary movement is the subtle micro-movements of the virtual humans' muscles, eyelashes or the digital hairs on the skin. In combination, it is a symphony of animated gestures that help to convince the eye that what you are seeing is believable.

Squash, stretch, and over-exaggerate are classical 2D cartoon animation techniques. If a character lands on a hard surface, they compress or squash into a pancake, then immediately stretch out into a long object, giving the impression that the character is invulnerable to any danger, but when stretched it creates tension, which preludes a burst of speed. In over-exaggeration, a character's gestures and movements are visually enhanced beyond reality to emote various forms of emotions and physical abilities.

When using motion capture, the animation is exactly as the real actor has portrayed it. When applied to a virtual human character, the mind rejects the movement as being 'too human'. As such, motion capture animators must also create artist-driven secondary and tertiary, squash, stretch, and over-exaggeration movement layered over their perfectly captured human motion capture data, so that the eye is once again tricked into believing what they are seeing is actual human movement, when in fact it isn't.

Figure 7: Adventure Man (2020) by Prof. Kris Howald, Sheridan College Computer Animation Program – Example of texturing and shading in Autodesk Maya.

Modelling, Texturing/Shading, Lighting, Rendering, Compositing, and VFX

Animation is only one element within the arsenal of tools required to animate an object. Virtual objects need to be modelled, textured, and lighted. Once the right combination of texture and lighting is achieved, the animated sequence is rendered into still images, which again are reprocessed to further enhance the final image or sequence of film by the compositing of additional 2D rendered foreground, midground or background layers, lighting, and VFX.

In virtual reality or interactive gaming, animation, texturing, lighting, compositing, and VFX are rendered in real time which requires substantive computing power. Unlike fully rendered 2D sequenced images, which use the computing power to render highly complex layers into photoreal animated sequences that are then viewed non-interactively, VR and interactive gaming cannot achieve a photoreal image in real time and their projected models, textures, lighting, and VFX have a less photoreal quality to them.

Modelling

The simplest object within any 3D space is a point. A point can contain X, Y, and Z coordinates, texture coordinates, normals (the front-facing direction of an object), animation channels, lighting coordinates, and a multitude of other meta- and paradata. However, a 3D point cannot be rendered unless it is given volume or mass.

If you have two 3D points occupying different X, Y, and Z coordinates, a polygonal spline can be created, which not only connects the points together into a new object but also acts like an actor-network (see Carter 2017a; Latour 2005), allowing points to share information between each other and the polygonal spline. Once three or more points are added with polygonal splines (lines) attaching to each point that is then connected in a loop back to the original point, a polygon surface or face is created in a triangular, square, or rectangular form. The more polygon faces an object has, the more the 3D model begins to have surface mass within the 3D space.

In 3D scanning, a technique now widely used in DCH, a real object is scanned by light shooting from a scanning camera, registering a point in 3D space as it hits the object being scanned (Ahmed, Carter & Ferris 2014). As such, scanned 3D objects have millions of points captured and formed into what is called a *point cloud*. Each point will have its own information created when the point is captured; however, every point within the cloud is in fact, autonomous to its neighbour. Only when polygonal splines begin to connect the points, either by hand or through an automatic software toolset, can the points share information such as texture and lighting coordinates and form actual 3D faces within the virtual environment. However, it does not capture a photographic texture.

Photogrammetry on the other hand creates a high-resolution 3D photographic envelope that represents the surface of an object. It cannot distinguish between the discreet parts of the object, so in the end what is captured is a 'blanket' of visual data information. Its 3D surfaces are approximated, meaning that it is guessed by the software system. Both photogrammetry and 3D scanning help to provide digital archives or visual representations of original objects, but due to the nature of how those objects or landscapes are brought into 3D space they themselves cannot be animated and can only be used as static 3D props or backdrops, unless broken apart, rebuilt as discreet pieces, and given the ability to be animated.

A model can have as many points and polygons as needed to create a 3D representation of the object the artist is creating; however, the more points and polygons, the slower the real-time rendering and final 2D rending of the image is, or the more power one needs from the computer's CPU and graphics card to interactively work with the model. This is why in 3D gaming the object and characters are more polygonal then in photoreal 3D objects in film, as both the point and the polygonal count has to be lower in order to achieve real-time interactive rendering.

If creating a model from scratch isn't your forte, then open-source online databases such as Sketchfab (https://sketchfab.com/museums) provide a venue for digital cultural heritage (DCH) practitioners to upload and exchange 3D heritage models for reuse.

Texturing/Shading

Texturing and shading have two different functions within 3D modelling. Textures on 3D objects are essentially 2D layered images that drape or wrap around the 3D object, or part of a 3D object. Shaders are 3D mathematical calculations that manipulate the actual surface of the polygon when rendered, thus giving textures specific properties to display.

For instance, in modelling a wooden ship, specific textures of 2D/3D images applied to the surface of the ship model would simulate the detailed look of those objects to give it the look and feel of an actual representation of rope, cloth, or wood. A texture and a shader are combined to give a dull or rough wooden surface of a ship's hull, or a shiny and reflective metal surface of the ship's cannons or the cloth-like feel of the sails. If one wants to create the illusion of ocean waves on the surface of a 3D landscape, the model itself would have an animated noise algorithm that makes the 3D surface undulate like waves. The shader assigned to that surface will also have animated noise algorithms to simulate the secondary and tertiary movement of the micro swells, ripples, eddies, and other water characteristics, but also the animated colour, lighting, and light refraction. The shader may be reflective and thus a model boat in the 3D water would be reflected on the surface of the water as well.

In many of the DCH representations and photogrammetry/3D scanning point clouds made into polygons, *grey shading* is used to give the object a sense of weight and light displacement within 3D space and to visualize the 3D object for quick editing or rendering. For many DCH examples, this half-finished look, becomes the final representation of the object, whether due to the technical or creative limitations of the DCH specialist. As such, the digital model lacks the materiality, colour, and texture, which grounds it within the context from where it came.

Lighting

Just like objects in the real world, 3D objects can be illuminated by various forms of light. Within 3D space, sunlight, moonlight, pitch blackness, or a misty haze can all be replicated by the various types of lighting. Although 3D, virtual, and gaming environments may have millions of lights within their scenes, three basic lighting techniques – fill, spot, and ambient lighting – help to generate the look and feel of the 3D objects within their environment.

Like daylight, *fill light* is omnidirectional, meaning within 3D space the light emanates all around. *Spotlights* are a concentrated unidirectional light, similar to the actual sun during daylight. Both can cast shadows by objects within the 3D space and work together to replicate the lighting in an environment. *Ambient light* casts soft rays in an omnidirectional mode, providing depth to the shaders. It casts no shadows and is used primarily for creating atmospheric lighting.

Rendering

There are two forms of rendering: pre-rendered and real time. Pre-rendered is when the 3D environment is made into a single 2D frame of film, which forms a complete animation of the character, object, or environment when combined with renders from a sequence. Pre-rendered images allow for a greater range of scene detail and photorealism. In real time, a gaming engine renders the objects or characters interactively, when in viewable range by the user. Because the 3D objects are being rendered in real time, the quality of the rendered image is solely based on the CPU and graphics card capacity to render complex scenes. As such, most game engine-driven renders tend to have lower-quality lighting, model, texture, and shader complexity. However, new hardware technologies are allowing for a smaller and portable form factor, combined with a higher CPU and graphics card capacity to eventually generate photoreal real time images. This is the goal for VR and augmented reality (AR) – to create immersive experiences of imaginary characters, objects, and environments within real-life settings.

Compositing

Compositing is a technique used to superimpose an image overtop or integrated within the broader 2D rendered scene. By rendering out in layers, artists have the ability to continue to manipulate the scene after it has been converted from 3D to 2D to tweak lighting, add VFX or new characters. In some instances, the compositing stage has been used to hand paint additional muscles on the bodies of live actors within a scene, to make them look more heroic. As in 3D animation, 2D composite layers can also be animated to enhance the secondary and tertiary motion within the overall final rendered sequence.

VFX

Visual effects, or VFX, are generally used to increase the believability of a particular scene or environment. Explosions, fire, smoke, sparks, water, wind, leaves, dust, dirt, and even crowds of background characters or spaceships fighting each other are all considered VFX. VFX is generally complex and, depending on the integration of the VFX in the scene, can be both 3D and 2D. Within gaming engines, VFX tend to be suggestive as opposed to being realistic, again because of the complex nature of the effect and the hardware rending available.

Tools and Techniques

To animate, one first needs to build an object, such as a character, in which to add motion. In 3D animation and gaming, this process starts with the modelling of the object within software applications such as Side Effects Software's Houdini, Autodesk's Maya, or Blender 3D animation software. Textures, shaders, and animation rigs are applied to the models and those animated models or static 3D objects/assets are placed within a larger 3D environment with other character and objects.

If the 3D environment is going to be user-driven, as in a 3D game, then the prebuilt 3D objects/assets are typically imported into either a Unity or Unreal game engine. At this point, the 3D objects/assets, if given the ability to be manipulated by the user using a game controller or haptic device, can then be moved, picked up, or affected interactively. If the 3D environment is part of an animated sequence and is intended as a passive 2D viewing experience, the 3D animation is rendered out to a sequence of 2D images and then into a video. If the intent is for the user to be completely immersed within the 3D environment, again a game engine is used to drive the user interactivity controls; however, the image is projected into a VR or AR headset as opposed to being rendered in real-time to a 2D screen. As such the user's physical motion is tracked and replicated within the VR/AR environment, allowing for the illusion of full immersion.

In some cases, handheld devices such as phones and tablets can be used to visualize 3D objects within physical spaces, but again the ability to see photorealistic images are limited by the CPU and graphics card capabilities.

Technical and Artistic Limitations

For most in the DCH field, the immediate technical limitations start with the laptop or desktop being used. To render and display 3D objects in real time, the computer needs a robust level of RAM, as well as a fast graphics card and CPU. Further, most animation software applications function best in a PC or Linux operating environment. In many cases, DCH funding does not allow for large-scale equipment purchases and DCH specialists. Multifunctional laptops, which tend not to be animation production-ready, are more practical in day-to-day use but not necessarily suitable for 3D animation creation.

Although almost all 3D animation software packages now offer a free student version for personal/research work, many of these applications also reduce the functionality, forcing students and researchers to eventually buy, lease, or borrow full-functioning tools to complete complex tasks or desired VFX not allowed in the free versions. Further, very few DCH academic programs teach 3D production other than a cursory introduction or not at all. As such, DCH hopefuls must hack their way through the steep learning curve to achieve basic 3D animation skills required to do their research or 3D projects.

Private DCH production companies such as LithodomosVR (www.lithodomosvr.com) have deployed traditional film, TV, and animation production techniques with consumer-level technology to create vibrant, materialized (re)visualizations of ancient worlds. These teams combine creative, technical, and subject matter experts, who work in traditional animation production pipelines, within the constraints of the software and the delivery platforms. VR and AR technologies at the consumer or prosumer level are at an effective price-point for DCH activities; however, budding developers quickly discover that functionality and features are inadequate in both ease of use and for the complexities of DCH entry-user needs.

Example

The DCH-making process is a wayfaring path (Ingold 2011). The tools, the material, the available data and knowledge, the moment in time, and one's skill all contribute to the construction of new knowledge and with that, a (re)visioning of the ancient past (Carter 2017c). Recent examples of 3D DCH production and research demonstrate a shift towards a professional theoretically and creatively grounded practice.

The *Slingsby Castle* reconstruction by University of York Master's graduate Bethany Watrous (Watrous 2018), with its highly curated and researched (re)visualization, demonstrates a new wave of academically trained 3D artist/DCH specialists who are rising to the challenge of bringing the past into the future. Watrous and a larger cohort of recent graduates in DCH represent a new form of 3D DCH production, where guidelines such as The London Charter and the use of paradata give promise to a theoretically grounded but animation-centric visualization of the past (see Denard 2012).

Professional 3D animation artists such as Bob Marshall represent a group of DCH creative practitioners who were traditionally trained in animation and

Figure 8: Warwolf – The Siege of Stirling Castle, 1304 by Bob Marshall.

then acquired their DCH knowledge through years of experience and project commissions. In *Warwolf – The Siege of Stirling Castle, 1304* (see Figure 8, above), he uses complex lighting, VFX, and character animation, combined with historical and archaeological data, to illustrate the tension and atmosphere in a slice of known history.

Beyond just visualizing within virtual space, Jonathan Westin (www.meltinghistory.org) from the Center for Digital Humanities at Gothenburg University, recently travelled in January 2020 with a team to the Antarctic to 3D scan, using a FARO system, a historic Swedish research outpost before it is lost to global warming. Apart from capturing the archaeological site digitally, the team also recorded light and specifically sound, to further incorporate within their future 3D virtual reconstruction. This process, which they called phenomenology, immerses the viewer deeper into the virtual world by adding, sound, touch, and smell (Cooper 2019; Jeffrey 2015).

Ubisoft's *Assassin's Creed* video game franchise, although not strictly DCH, represents an achievement in the application of 3D animation within a DCH-inspired virtual environments (see Ávila, Corso & Fischer 2020). The gaming company has taken a proactive community-engaged approach when conducting background research on any of their titles that deal with cultures not their own. Ubisoft actively employs a historian and a team dually trained DCH specialists to support the attempt of historical and archaeological accuracy within the franchise. They also have the budget and resources to digitally capture existing historical architecture, which is then used as 3D assets within the games. As a result of the recent loss of the structural integrity of Notre Dame due to fire in 2019, Ubisoft's 3D-scanned interiors and exteriors have played a part in the restoration planning and process to slowly rebuild the cathedral to cultural heritage standards (Ávila, Corso & Fischer 2020).

Discussion

The birth of virtual/digital archaeology can trace its roots back to 1987, when mainframe computers were required to render even the simplest grey-shaded object to screen (see Reilly & Richards 1987; Reilly 1991). Desktop computers would take almost another decade to become ubiquitous, and it would take even longer for the cultural heritage community to embrace this new technology. Many DCH examples over the last four decades are still missing the engaging and life-giving qualities of animation. We now compete with the public and institutional desire to consume high-quality digital media. Whether due to the lack of artistic or technical animation skills, access to technology, or the cost to produce, DCH continues to be overshadowed by the robust technical and creative advances and substantive budgets in the entertainment industry and as such, our own inability to fulfil those expectations.

Unlike entertainment-based animation, where the digital assets, environments, and digital people are the creation of the writers, producers, and artists who are free to mix and mingle historical or fantasy influences, DCH practitioners have a 'duty of care' in representing the cultural, historical, or archaeological unknown (see Perry & Taylor 2018; Huggett, 2015, 2017, 2018)held in Oslo. The theme of CAA2016 was 'Exploring Oceans of Data', alluding to one of the greatest challenges in this field: the use and reuse of large datasets that result both from digitalisation and digital documentation of excavations and surveys.

What does this mean? Any historical representations of past cultures, whether Roman, Mayan, or Nubian, are based on academic speculation, surviving artwork that may depict how certain objects or people looked, or colonial accounts, which are for the most part are laced with highly racist and stereotypical representations of the 'other'. As such, DCH practitioners in many cases (re)visualize the historical unknown.

When there is a gap in the knowledge, an educated guess is made and then visualized. Unlike entertainment-based artists, DCH practitioners must explain how they filled the gap in knowledge, what sources they used, and if no sources were available, how they were able to construct new knowledge and present an alternative (re)visualization. This is called 'paradata', which in effect is a recoded diary of all of the decision-making choices a DCH practitioner makes to build or construct new 3D objects, data or knowledge (Baker 2012; Bentkowska-Kafel, Denard & Baker 2012; Denard 2012). Thus, our duty of care is to not only visualize the cultural, historical, or archaeological unknown, but to also provide an explanation as to how one arrived at making that digital representation, in the most ethical, equitable, culturally considerate, and scientifically enabled way (see Dennis 2020)

Considerations

On the horizon, digital cultural heritage promises to be a scientifically and culturally valuable asset in representing the cultural, historical, or archaeological unknown. However, the potential ability to create 3D models in software packages such as Blender, or to access and reuse open access heritage 3D assets in Sketchfab, or the ability to combine assets within a real-time game engine such as Unity or Unreal then interactively engage with them in virtual space through an Oculus or HTC VR system, hasn't become easier for either novice professionals or consumers yet. Creative and technical skills acquired through being self-taught or through additional technical animation courses, combined with cultural heritage training, is still required to bring past worlds to life.

Over the last 10 years, universities such as the University of Glasgow, University of York, University of Dundee, Bournemouth University and especially Glasgow School of Art have embraced digital cultural heritage and now have actively combined programs and courses in animation and cultural heritage. As such, digital technology practice and the heritage sector have begun to converge, and this has created a new generation of digital cultural practitioners.

One of the greatest risks digital cultural heritage specialists face today, is the pervasive hyper-realism of the constructed 3D image. As software, hardware, and actual skill sets have been simplified, both professionals and consumers can, with some practice, create life-like images of ancient landscapes, peoples, artefacts, UFOs, and dinosaurs. The mundane can now be digitally replicated in uncanny realism (see Mori, MacDorman & Kageki 2012). As such, those constructed 3D environments can be misconstrued as being 'real', and there lies the danger of being able to visualize or reconstruct the 'unknown' without providing the context or research to support the (re)visualization being presented.

Conversely, should DCH specialists be the sole authority on what should and shouldn't be digitally culturally represented? What about indigenous, people of colour, or colonized voices? Does this technology allow underrepresented community stakeholders to also visualize their perceived pasts, in a manner representative of their cultural considerations? Who decides what is culturally, historically, or archaeologically accurate?

Large game companies, such as Ubisoft, now actively create new cultural-historical entertainment products that not only (re)visualize the ancient past, but retell stories and narratives in a convincing and engaging way. Ubisoft, in particular, has gone to great lengths to include community engagement when representing ancient peoples, cultures, objects, and landscapes in their historically influenced Assassin's Creed gaming franchise. But what happens in the future when this approach is too expensive or accidentally or intentionally misrepresents history in a way we know is categorically untrue? What if the consumers of these entertainment games, TV series and films begin to believe in what they are seeing is a real representation of history, only due to the fact that the digital (re)visualization of people and places is so effectively lifelike?

Lastly, what is our role in digital cultural heritage? How, as potential and active practitioners, can we engage reflexively, thoughtfully, creatively, technically, and academically within this ever-expanding field through the creative and communicative medium of animation? What is our 'duty of care' and how do we ensure community involvement and engagement when representing past histories from a culture that is not of our own?

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