Virtual Reality Environments: Preservation

A multi-disciplinary study into the impact of digitlally preserved environments and their use when paired with virtual reality.

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Contents

Study Introduction

Virtual Reality, once seen as a gimmick in entertainment, has been gaining traction and is now recognised as one of the technologies with the highest potential for growth.

With communications giant Ericsson predicting that by 2030 we will be able to enjoy full digital environments that appear completely real to all the 5 human senses simultaneously, the importance of lifelike virtual environments is increasing with demand present in varying sectors. (1)

This study delves into digitally preserved environments across 4 varying disciplines. With a focus on the derived benefits, the role that virtual/augmented reality plays when taking advantage of these environments and the potential future implementations/conflicts.

Virtual Reality (VR)

VR refers to the use of computer technology to generate a digital environment to immerse a user in. Using headsets like the Oculus Quest and with a combination of video/audio a user can interact with and move around in a simulated experience. True VR will aim to stimulate as many of the human senses as possible. (2)

Augmented Reality (AR)

AR involves a streamed view of a live environment with supplementary computer-generated graphics or overlays to enhance the viewing or add interactivity. Common uses include snapchat filters which augment images from a smartphone, as well as mobile games such as Pokemon Go. Augmented Reality headsets are in early stages of development, with Microsoft's HoloLens being the most prominent example. (2)

Photogrammetry

Photogrammetry is the science of extracting measurement information from photographs.
Size, shape, and measurement details are captured from multiple angles in imagery and stitched together into a point cloud. From this, 3D objects from the real-world imagery can be extracted along with photorealistic textures, this is used extensively to create photorealistic environmental assets for video games and film. (3)

Digital Environments

Digital environments have become commonplace in the 21st century, with most people being exposed to one through either film or game. The creation of virtual environments is used across a wide range of sectors – from manufacturing to architecture, used as a method of visualisation or an escape from reality.

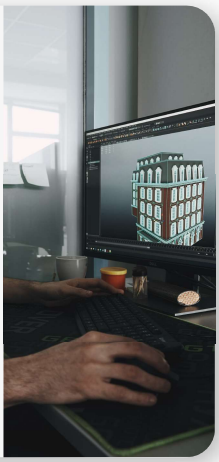
Preservation, defined as the protection of the environment from harmful human activity, is extremely important for sustainability and the quality of communities. Where the most successful preservation efforts benefit from shared responsibility between governments, local communities, and organizations. (4)

Where these efforts used to be manual and tedious, varying technologies have allowed for the digitization of preservation work and enhanced workflows. With increased computing power, the archiving of photographic, audio and video collections are becoming an easy way of maintaining an untapped source of historical evidence and replacing old methods such as blueprints and paintings.

Creating digital "Twins" of items and locations which can be later utilised for education or restoration purposes. (5)

Manual 3D Creation

- Utilises specialist software to create a shape/object in 3D space by hand.
- Textures are manually painted onto geometry and left to artistic interpretation.
- Used commonly for many years across multiple industries.
- Requires high skill level, and very time consuming.



Photogrammetry

- Extracts 2D and 3D data from scanned imagery, measurements, and recordings.
- Textures are automatically projected from imagery.
- Becoming popular for creating photorealistic assets for game and film.
- Requires licensed software, relatively low skill level, and very fast for initial results.

Accessibility, Data, Trends

Recent years have seen significant development progress in image alignment, surface reconstruction and information extraction (the key technologies for photogrammetry). Aided by advancements in both camera hardware and machine learning/statistics, workflows for this technique have become streamlined and better suited for non-specialists. The global photogrammetry market is now valued at $713.1 Million, with higher growth anticipated as the software matures further – this impressive growth is testament to how it has been integrated into the pipeline of many industries. (7)

The table to the right shows a wide range of software offerings which tailor to specific platforms and use cases. This wider choice for software, and the existence of open-source packages, has encouraged larger adoption and makes photogrammetry accessible for even a hobbyist or indie developer. With 3D reconstruction becoming a mainstream subject in computer vision, photogrammetry will continue to reap reward from the research efforts of a much larger community.

"The impressive growth of drones and their improving autonomous navigation capabilities is opening to photogrammetry another, still unchartered, world of applications" (8)

Software	Platform	License Cost
Originated from 3D Models or Scanning:		
3DF Zephyr Aerial	Windows	€3900 (+20%/year)
Reality Capture	Windows	€4000 (+25%/year)
Agisoft Metashape	Win/Mac/Linux	$3500
Photomodeler	Windows	$3000 or $1250/year
Originated for UAV or Aerial Drone use:		
Pix 4D Mapper	Windows	€4000 or €2600/year
SimActive Correlator	Windows	$6400 or $3000/year
Terra Mapper	–	$3700 (+$700/year)
3D Survey	Windows	€3000 or €2400/year
PixProcessing	Windows	€2050/year
DatuSite/DatuSurvey	Windows/Android	$2500-$4600/year
Drone Deploy	Cloud Based	$1000-$3000/year
Maps Made Easy	IOS/Web	$0.05 per acre
Open Source		
Open Drone Map	Web	Open License
Visual SFM	Win/Mac/Linux	Open License

Range of software for photogrammetry covering the spectrum of costs and capabilities available today (6)

Preserving Culture

Why Preserve?

Historic and cultural preservation is seen as an important investment in the present and the future, with many charita ble organisations striving and maintaining global efforts. The preservation of historical sites provides a deep link to the roots of local communities as well as the people that currently or previously inhabit them (10).

The benefits of cultural preservation span economics, environmental as well as educational sectors. At face value, the digitisation and archiving of data around historical sites is extremely important to protect against further damage. If the environment was to be captured accurately for use within VR, then reconstruction efforts could be less strenu ous, as reference would be accessible easily. Another key benefit is that these sites inspire wonder and curiosity in the history of locations and the communities – which is extremely important when trying to educate on historical events, future damage or even generate tourists.

The Impact Of VR

It is argued that the best way to understand cultural heritage is to experience it in a way that is a realistic as possible, this is where VR and AR technology can excel. VR experiences of reproduced sites can allow for an unparal- leled level of interaction, reduced barriers when viewing all parts of a site/object as well as potential to view the same site at different stages of time. As mentioned in a recent study, VR experiences can serve to illustrate the main contexts of the "life" of an artefact, its manufacturing context, its day-to-day usage, and its final use when it was disposed. (11)

Examples of full VR implementation in this sector are still rare, where mostly 360 videos have been more popular. Resonant VR (CyArk) is a leading example of how an immersive VR experience can be created based on a historic site, where communities are able to leverage the technology to showcase the sites beauty as well as tell the story and origins of certain traditions. (12)

World Heritage Sites (9)

1,121
Recognised

869
Cultural Sites

35
Cultural Sites In Danger

CyArk

CyArk is a not-for-profit organization, that for the last 15 years of operation have set out to digitally archive and share the worlds most significant heritage sites. With recordings of over 200 monuments on all 7 continents, CyArk leads the digital preservation of the sector and has even partnered with Google Arts to make all resources accessible on the web. The use of scanning and photogrammetric techniques allow for a highly accurate replication to be captured, with all data then being archived for the potential need in disaster recovery efforts. Recent efforts include the creation of further immersive VR experiences that leverage their knowledge and data. (13)

Virtual Conservation

Why Preserve?

The reasoning for the preservation of environmental areas such as coastlines and oceans are akin to those of historical sites. These natural areas of beauty are undergoing constant damage, mostly from man-made acts such as deforestation or pollution. Modern individuals can often find it extremely challenging to identify with these issues, as their day-to-day life is very disengaged, and they are not exposed directly to the issues. The reasoning therefore can be hard to understand until visiting such a site and being exposed to the impacts of our actions.

This struggle to educate/persuade is a real problem in areas such as climate change, where public opinion is changed hugely when large environmental events become public through damaging imagery and or video. An example of this is the Amazon rainforest fires of 2019, where the huge media attention and social media campaigns drove awareness and showcased the graphic requirement needed for environmental conservation to succeed. (14)

The Impact Of VR

"Anecdotal evidence from philanthropic fundraisers shows that virtual reality (VR) technology increases empathy and can influence people toward pro-environmental behaviour. Non-profit organizations are increasingly marketing their causes using virtual reality and they report increased donations when VR technology is employed." (15)

The ability of VR to convey the beauty, damage and vulnerability of an environment and habitat is extremely powerful. AR could also be used to employ "Looking glass" type experiences locally on sites, where visitors are able to view visual overlays labelling points of interest, or perhaps even having the ability to view a particular area at a much older point in time.

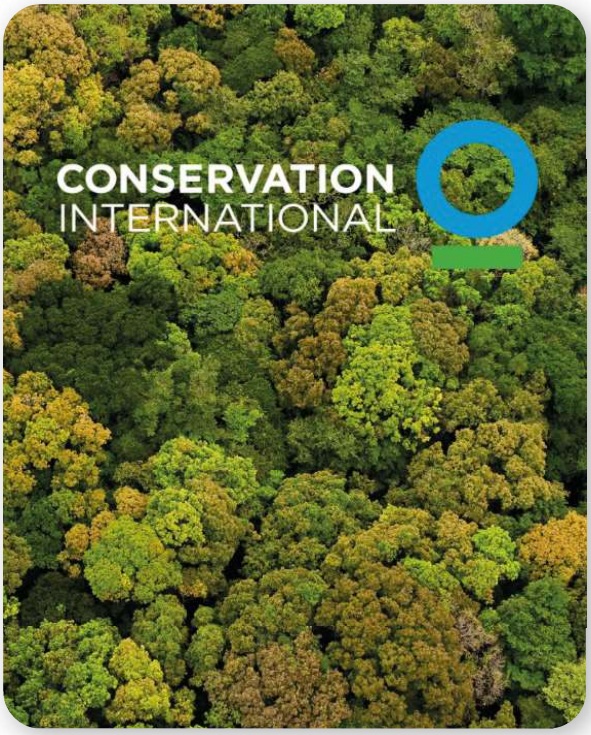
Conservation International

Conservation International, another non-profit organisation, has worked to spotlight and secure the critical benefits that nature provides to humanity since 1987. (15)

One of Conservation International's most successful restoration projects took place in a remote location in Indonesia called Bird's Head Seascape. From the US. east coast, it takes four flights, one boat ride and more than 40 hours to travel there. The region covers an area the size of Great Britain.

Conservationists found that the best way to inspire policymakers, business leaders and citizens to engage and invest in conservation was to take them on a site visit to experience these worlds. Again, showing parallels to the cultural preservation, where a user's presence and experience is key for understanding – especially in the case of environmental damage.

The resulting solution was CI's virtual reality film Valen's Reef, where the area can be experienced in just 7 minutes. Whilst the VR solution was a simple 360 video player and had limited interactivity, it allowed a much wider audience to experience this area in need of preservation, With a social media strategy resulting in over 2.6 million social impressions and nearly 1 million YouTube views. (16)



Tourism Substitution

The tourism industry is currently taking advantage of digital environments and virtual reality for marketing tourist destinations. The ability to capture a location in a memorable and much more immersive way creates powerful marketing tools but also can provide alternatives for individuals who cannot visit in person due to mobility, financial or time restrictions. Virtual Reality offers a more engaging form of destination advertisement that makes users feel as if they are participating in an activity rather than being blatantly sold to.

The technology could however be used to eventually create virtual experiences that customers accept as substitutes for first-hand travel. In cases where a destination could be too dangerous or simply no longer exist, a preserved digital rendition would allow the world to still be experienced in an immersive and more accessible way. A unique twist on this is the VR flight experiences that became more popular due to COVID-19, replicating the experience of flying in a consumer airliner without the physical travel itself.

Current Use Includes

- Virtual hotel tours by travel companies and hotels
- VR travel experiences for the elderly
- VR flight experiences
- Virtual experiences of landmark destinations and film.

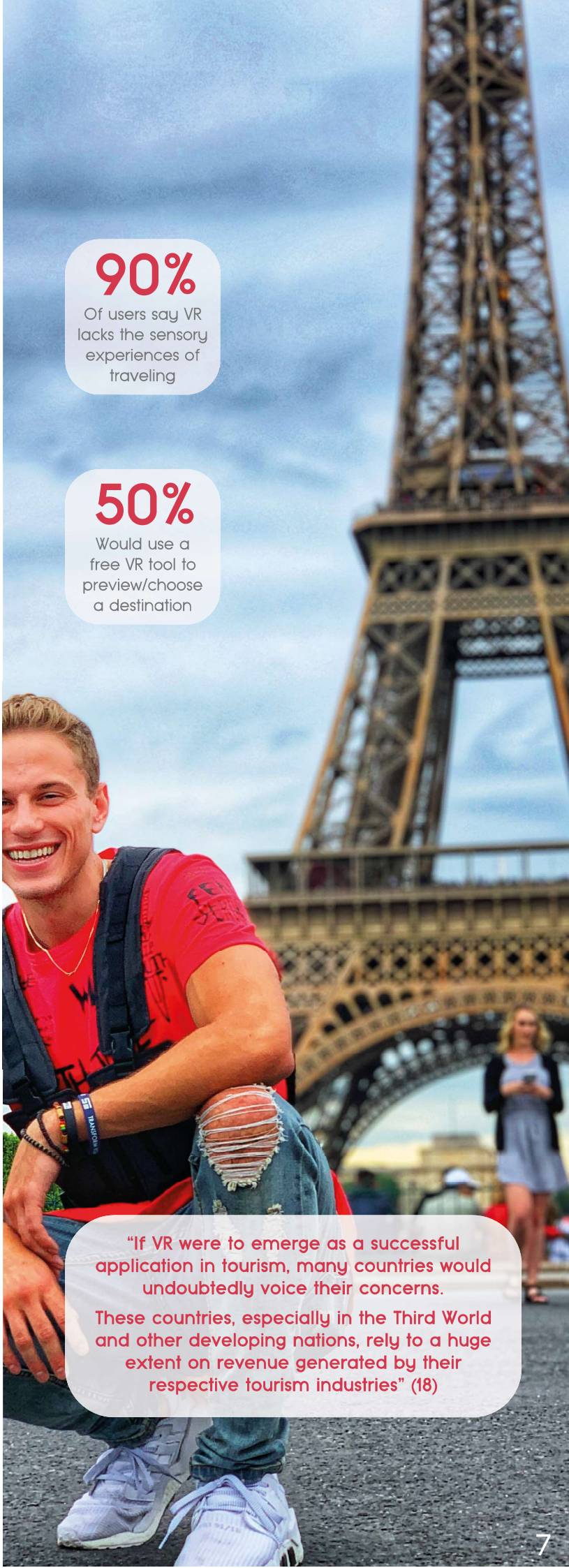
The Impact Of VR

Recent research carried out by Statista in Germany found that almost 50% of people would take advantage of VR as a tool to help choose a holiday destination (given it was free), with an additional 13% willing to pay for the premium. This insight demonstrates the power of virtual reality and how it can best portray replicated environments in an engaging method to potential customers.

However, whilst these studies show VR as a beneficial marketing tool, especially in remote locations, it does not appear to show a direct threat to 'real' travel. In the same study, 81% of adults did not believe VR could replace future travel and nearly every participant (92%) would not consider giving up a physical holiday for the digital counterpart. The overarching reasoning for this seems to relate to the forgone sensory experience of physical travel when compared to the virtual – which perhaps as developments in VR space incumber more human senses, the likelihood of substitution could increase. (19,20)

90%
Of users say VR lacks the sensory experiences of traveling

50%
Would use a free VR tool to preview/choose a destination



"If VR were to emerge as a successful application in tourism, many countries would undoubtedly voice their concerns.

These countries, especially in the Third World and other developing nations, rely to a huge extent on revenue generated by their respective tourism industries" (18)

Crime Scene Replication

Why Preserve?

Crime scene reproduction plays a significant role in crime solving by helping detectives to determine the course of events surrounding the crime. Each scene will boast a different level of complexity and with every investigator owning an individual perspective – it can be very easy for the most aware detectives to not recognize evidence immediately. The preservation of evidence is key for a trial and conviction, any delay to this can allow for alterations and degrading of its value to the case.

The goal of forensic documentation is always non-invasive, high-resolution measurements to gain increased insight to what can be found from initial viewings. A plethora of documenting techniques are already being used for the preservation of a crime scene, with 3D data recording methods providing precision that does not succumb to spatial distortion that is often abundant in 2D counterparts. With recent advances in software and more accessible equipment, police forces are now regularly able to capture and utilize 3D data to document/preserve a crime scene. (21)

"The suspect can be visually taken back to the crime scene without physically leaving the interview room"

A large database of scanned objects could be formed from a magnitude of crime scenes, Similar to current face databases (23)

The Impact Of VR

The application of VR within this discipline allows a more accessible method of interacting with the recorded 3D data and can bring huge benefits when walking a third party through a chain of events. The comprehension of a scenario, as well as spatial memory of a complex crime scene can be increased, making persuasions of non-specialists easier. As well as this, the accuracy of the environment would allow a detective to non-destructively interact and walkthrough potential events, allowing quick iterations but also a first-person perspective that does not hinder physical evidence.

Whilst the advantages of VR in a courtroom include improved persuasiveness, additional evidence, and much greater attention – the admissibility of these environments are exposed highly to risk of bias and potential abuse from the ability to edit. A recent study suggested that VR and digitally preserved crime scenes are a promising medium for the court room, especially in the case where physical viewing is not possible. (22)

Caught Virtually Lying

- This research study explores how virtual reality could be used when interviewing a suspect and demonstrate that they do recognize a crime scene despite them claiming not to.
- Participants started by committing a mock crime before being incentivized to conceal recognition of any crime related details (The environment, the stolen items).
- The entire crime scene was then laser scanned, converted using photogrammetry to realistic 3D models and then presented in 2 methods. Method 1: Virtual reality viewing, Method 2: 2D Imagery.
- Concealed recognition was measured using a Concealed Information Test (CIT) with recordings on users heart rate and skin conductance.
- The detection of concealed recognition increased by over 25% when participants viewed the crime scene items in VR when compared to traditional 2D Imagery. Demonstrating the effect that photorealism can have on a user, and how much more immersive this approach is. (23)

The Future

The nature of any act of preservation requires action to be taken in the present to benefit future generations and protect environments. As discussed at the start of this report, the technology has grown impressively over the last few years and is more accessible than ever for a wide range of users and disciplines, but simply needs a push for wider adoption. The benefits for virtual preservation have been shown to be plentiful across culture, environmental, tourism and policing sectors – with no doubt a host of other subject areas that can benefit from a much more immersive method to viewing and interacting with realistic digital locations. With the world become more connected, and forecasts for Virtual/Augmented reality to become a staple part of everyday life, the justification for digitally recording and preserving important environments is certainly existent. As natural disasters and man-made incidents become more frequent, this present act could aid recovery efforts in the years to come but also allow more immersive education, persuasion, and heritage connectivity.

Complicactions

The rewards of this technology however do not come without their own set of complications and challenges. The biggest issue with digital preservation is the ability for bias and control of information as mentioned by Refsland et al. "How far does artistic interpretation go before it impedes on historical accuracy and convinces a young virtual visitor that history was something that it's actually not?"(24) . This refers to the fact that many individuals and corporations may use the technology to sell/attract users to a location and therefore will only be interested in showcasing the most attractive sections, perhaps intentionally missing certain areas or information leaving a user miseducated. This can be extremely dangerous in the case of historical events and could corrupt future generations vision on what truly happened.

As well as this, there could arise issues with intellectual property – especially in the case of tourism, raising the question of whom the landmark/environment belongs to for financial reward? But also, is revenue classified as entertainment (VR) or tourism?

Lastly, for areas like tourism – the success will be deterministic on the ability to create environments that can stimulate all human senses at the same time for upmost realism, which we are not yet capable of achieving. Other barriers to adoption in this sector also lie with the lack of spontaneity and inability for physical souvenir purchasing – which are issues greater than the technology itself.

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