WILLANDRA LAKES FOSSIL HUMAN TRACKWAY: Presentation and Protection

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ABSTRACT
The Willandra Lakes Region was nominated and inscribed in the First round of World Heritage Listings in 1981. It is a mixed site that has unique universal values for both natural and cultural criteria. Since listing the Willandra Lakes Region has continued to expand its portfolio which includes the recording of the Willandra Lakes Fossil Trackway.

The Willandra Lakes Fossil Trackway was unearthed in 2002 through natural forces. More than 500 footprints have been recorded within 22 trackways. At 20,000 years old, it is the most extensive known human fossil trackway in the World. The site has high levels of spiritual, cultural and scientific significance.

The fossil trackway captures a moment in time. A record of an event, a family crossing the landscape sharing their experiences. This is borne out with the evidence of a hunter, throwing a spear and missing a Kangaroo. A child meandering, cutting the path of the adults as they walk behind. A mother carrying a child and shifting the weight from one hip to the other. A one-legged individual, possibly assisted by a walking stick.

To assist with management and monitoring, the site was 3D laser scanned shortly after it was exposed. Selected footprints and trackways were also recorded with latex peels. Under the direction of the Aboriginal Advisory Group we are using this data, to monitor impacts to this unique site as well as to present and tell its story. This data can be used to reproduce off site scale replicas of the site, augmented reality experiences that enable people to walk with this family and bring their experience into the present. Other uses include teaching aids and digital storybooks.

This case study is practice-led research focusing on applications of 3D data capture in areas involving human experience, interaction and culture to consider how this will affect the interpretation and delivery of information. In collaboration with key stakeholders and industry experts, practical 3D reality capture examples in areas of human experience such as heritage preservation, forensics and medical imaging will be used as test cases for benchmarking and to develop accurate workflows in 3D digital technologies for the capture, analysis and presentation of 3D data.

3D laser scanning technology is available for almost every situation and the advantage of 3D data capture in these environments is that it is non-invasive, the object or site to be scanned can remain untouched and undisturbed. 3D scan data can be highly accurate and reduces the risk of human error, it is also a three-dimensional record of information that is vaulted for future reference, comparison, analysis and accountability.

In addition to preservation and analysis, the emerging worlds of 3D printing and immersive realities compliment the use of 3D data to accurately communicate “real-life” objects. This research predicts how these technological innovations will continue to develop and also how combining these with 3D data capture may impact end users’ lives.

This case study can demonstrate how quality data collection for monitoring and management purposes can be reapplied and adapted, with little effort, for presentation and promotion of World Heritage properties. In turn this approach enables the long-term protection of the site by reducing impacts from visitation.

Keywords
Fossil trackway; Willandra Lakes; Australian Archaeology; Heritage Preservation; Interactive Experience; 3D Scanning.

INTRODUCTION
The Willandra trackway is a hidden treasure of Australian human history. It allows us a very personal link to the past human lifeways of Australia that stretches back beyond the history books. The ancient trackway is located in the Willandra lakes region, in a world heritage listed site that is part of the Mungo National Park. The Willandra Lakes, as we see them today, are a dry, sandy and arid region in the far west of New South Wales in Australia around 700km West of Sydney (see Figures 1 and 2) [1]. Each year more than 50,000 tourists visit this region for its historic significance, each trying to make a personal link back to the Australians of 20,000+ years past [2].
The Willandra Lakes Region was nominated and inscribed in the First round of World Heritage Listings in 1981. It is a mixed site that has unique universal values for both natural and cultural criteria. Since listing the Willandra Lakes Region has continued to expand its portfolio. The region's historic value, and the reason so many tourists visit, comes from its many priceless historic sites and artefacts, all of which stem from what must have been a vibrant indigenous community that lived there for more than 40,000 years (and whose descendants continue to do so today).

The region is characterised by a range of areas and sites of global interest. People have used the Willandra in some way or form continuously for at least 50,000 years. The oldest sites go back before 50,000 years ago. An age once considered contentious, as it forces re-thinking of global migrations routes. However, now with the Australian archaeological record demonstrating >50,000 sites as common, it is no longer contentious but broadly supported [2,3,4].

Although there are many sites and items of interest in the Willandra Lakes region, one of the most widely known and readily identified of these is the Willandra Trackway.

**Willandra Trackways**

The Willandra Lakes Fossil Trackway was unearthed in 2002 through natural forces. More than 500 footprints have been recorded within 22 trackways. At 20,000 years old, it is the most extensive known human fossil trackway in the world. The site has high levels of spiritual, cultural and scientific significance.

The fossil trackway captures a moment in time. These sets of ice-age footprints, embedded into the clay-pan by our first Australians walking or running across the clay-pans and leaving their footprints preserved in the mud (see Figure 7 & 8), are a record of an event, a family crossing the landscape sharing their experiences. This is borne out with the evidence of a hunter, throwing a spear and missing a Kangaroo; a child meandering, cutting the path of the adults as they walk behind; a mother carrying a child and shifting the weight from one hip to the other; a one-legged individual, possibly assisted by a walking stick. In time these footprints have hardened and were covered over with sand and sediment, to then, eventually be uncovered by shifting sands/erosion and found by Traditional Owners when out of a Cultural Heritage survey. The Willandra Lakes Fossil Trackway was unearthed in 2002 through these natural forces [9,10,11,12,13,14].
The erosion that impacts the site means that areas are being exposed and recovered on a regular basis and new finds are an ongoing outcome of this situation. The nature of this covering and uncovering has provided an ideal environment for trackways to be protected for long periods. In the case of the well-known Willandra trackway which were only recently discovered, there may well be many others hidden beneath the sands of the Mungo National Park. Detailed research and analysis has identified that the preserved footprints are around 20,000 years old and contain not a single person’s track, but a combination of tracks including men, women, and children engaged in differing activities (walk, run and playing). Due to the quality of their preservation it is possible to understand something of the story that each set of footprints holds.

Although these major finds have been most widely reported, the region has numerous other sites and items of interest, all of which add to the rich tapestry of ancient life stories that the region holds. In many ways it is not purely the data of the sites and artefacts that are critical, but also the stories that they tell, and the stories that have been passed down through the indigenous communities who live there. Only when we bring all of the pieces together can we create an engaging digital virtual experience.

1. THE STORIES OF WILLANDRA

As indicated, there are many valuable historical stories hidden within the Willandra lakes region. From the long term (geological time based) environmental changes that saw the region go from an inland sea, to a series of lakes, to drying lakebeds (when footprints were pressed into soft shallow mud) and eventually a dry arid space (as we see today). These long time-frame stories sit alongside the more human stories of the ancient ice-age Willandra communities; featuring people that lived along the drying lakesides (these would include Mungo Lady, Mungo Man and the people who made the trackway footprints). Much like today, people have a tendency to live near water and the ancient people of the Willandra region appear to be no different. Archaeological analysis of hearth remains and sediment layers from this ice-age period indicate that the Willandra waterways held fish and shellfish and that the earlier people (when lake water levels were high) would most likely have lived an enjoyable lakeside life. As the ice-age period approached the water levels in the lakes dropped leaving wet claypans. For visitors today, it can be hard to imagine a lakeside world (given its remote and arid setting) but such a world existed for our ice-age Australians.

1.1 The Trackway Tells Us More

The wonderful thing about the trackway is that it is large enough (currently around the size of a standard tennis court, see Figure 9) to give us more than a single footprint. Instead it offers a form of historic story (or in this case stories) captured in the clay. An excellent example of this is the set of tracks that, capture a moment in time, 20,000 years ago, of a group of people crossing the clay-pan [11,12,13,14,15]. The group consisted of several adults, adolescents and children (perhaps a family group) while other tracks present also include birds and the older finger flutings. Archaeological analysis has been able to identify these individuals through the size of footprints, stride length and depth of mud penetration. Understanding the characters in the scene is only part of what the trackway can tell us. In this case we see the group of prints walk across the pan, but we also see a set of footprints break away to the side, then turn and come back. These prints are those of a younger member of the group (with a smaller footprint). It is easy to imagine a family group where a young child wanders away and is called back. Although a simple story it is this human touch and the obvious links to any young family today (with the common story of youngsters who wander off) that helps us gain a sense of understanding and association with Australia’s oldest known people. In addition to the family tracks, the trackways hold other series of footprints that are
just as engaging. In one there is a set of larger/heavier prints (most likely men) that are moving more quickly (larger stride length and deeper mud penetration), in fact running. Once again it is easy to imagine a hunting party chasing prey or a number of other possible, very human stories.

The footprints are easily recognized, as humans, but there are also other marks in the claypans that may tell us stories. An example of these is a set of small crescent shapes, believed by some, including the local Pintubi people, to be marks made by children in the claypan [14]. Although this possibly true story is harder to confirm, it highlights an important part of generating engagement with the viewer. Being a contested story in no way makes it less relevant, in fact, the fact that it is contested makes it something of interest to an audience, as they want to see it and judge for themselves. Much like the trackways, where the viewer can imagine how the people behaved, the possible finger artworks and marks have an element of the certain but also an element of the unknown which needs to be imagined.

Archaeological and scientific analysis plays a crucial role in obtaining and clarifying the known details. The potential to use this information to then create a framework, in the form of a digital interactive system (game/augmented reality/virtual reality) into which the viewer could enter and experience the environment offers potential and is the core concept behind this research project.

1.2 The Hidden Story
The wonderful stories described are tightly linked to the actual trackways, and the ability for people to imagine the possibilities relies on them being able to experience those very trackways. Unfortunately the real physical trackways (as seen in Figure 8) are fragile and at risk of damage (from both people and environmental factors (erosion, changes in underground water level cracking claypan)). In order to protect the site it was, in 2007, covered with sand (much as nature covered and protected it for thousands of years). Figure 9 shows the physical site today (including its full sand cover), and sharply highlights the need for other mechanisms for the broader community to experience and gain connection with the valuable trackway and the stories of the region.

![Figure 9. The hidden trackways](image)

As is the case for so much history and culture, the greatest source of information is the people themselves. In the case of Willandra we are fortunate to have the descendants of the very people who made the footprints, still living in the region today. The regions indigenous tribes actively seek to keep the history and culture alive, as the Visit Mungo website states [2]:

“The Paakantji, Ngyiampaa and Mutthi Mutthi people walk here in the footsteps of their ancestors, ensuring their children grow strong in their culture. The tribal groups also seek to share their knowledge of Country with visitors to Mungo National Park.”

Capturing these human stories, passed down through the generations is just as, if not more important than the digital and archaeological data capture, and it plays a key role in how this research project seeks to develop the digital experiences for the Willandra lakes.

2. 3D DATA CAPTURE & LASER SCANNING
The Willandra trackway has been actively analysed over an extended period. The bulk of this work has been archaeological study focused on academic knowledge. This research project focus is on utilising the pool of academic knowledge, linking it to cultural stories from the tribal groups and combining this with leading edge digital data capture techniques.
To assist with management and monitoring impact to the site, the trackway was 3D laser scanned shortly after it was exposed and selected footprints and trackways were also recorded with latex peels. The 3D data attained from these scans (Figure 10) now becomes the basis for information to be used to present and tell its story; and to finally produce interactive immersive experiences that allow the user to engage with the world of the Willandra trackway through digital means including Virtual Reality, Augmented Reality and gameplay.

Figure 10. 3D scan data of footprint CH1_1_1

2.1 Post-processing and Deliverables
Through conversation with the three Traditional Tribal Groups (the Paarkindji, Ngyiampaa and Mutthi Mutthi), NSW National Parks and Wildlife Service, and archaeological experts there were a range of possible outcomes that were targeted relating to the 3D scanning of the Willandra trackways:

1) 3D printed replicas of trackway site
2) Establish a web-based viewer for analysis and teaching
3) Introduce and present workflows to the Mungo Youth Project
4) Develop interactive augmented reality visitor experience for mobile devices to bring to life the stories surrounding the trackways through digital animation
5) Generate augmented reality hotspots to give interesting information and accounts by touching mobile device screen

These target outcomes align with many virtual archaeology projects, with accurate capture and recording playing a key role, but also interactive entertainment (through VR/AR and related systems) and its use in better presenting and understanding the story of what occurred. The forensic archaeological analysis plays an interesting role in the later, particularly from the entertainment perspective. Through the 3D scanning/capture element, a data set of very high quality is obtained. Such data, through the analysis of the footprints and the surrounding area, and the understanding of Aboriginal culture and experiences passed down through generations, when placed in a VR simulation, can be used to reconstruct the story surrounding the significance of the scenario and what occurred 20,000 years earlier to produce the trackways.

2.2 Presentation – Turning Data into Story
Developing story, based on truth and established from captured information involves a complex set of analytical tasks. Research deliverables from the analysis of the 3D scan data of the footprints may be divided into two main technology paths; Interactive Experience and Forensics. This combination of entertainment and science becomes the building block allowing us to use 3D scan data to accurately recreate the events surrounding this important landmark. Combining the data sets including, 3D GIS data, 3D detail terrain model, with forensic archaeology and story accounts from Aboriginal elders, we are able to reconstruct, in an immersive virtual sense, an accurate story of the Willandra trackways.

Both require new innovative processes for analysing and communicating point-cloud information from the captured 3D scan data. Scans of large-scale items, such as the Willandra trackways, generate large data-sets. Managing the data and enabling its use at an appropriate level-of-detail for the differing tasks is critical. The size, accuracy and complexity of the raw information, when registering and post-processing 3D scan data, needs to be considered. The workflows undertaken in this area by Smithsonian Institutes Digitization Program Office, CyArk and Historical Scotland’s Digital Documentation team for digital heritage preservation and management of large data sets provided existing methods for this task [15, 16, 17] and outlining them is beyond the scope of this paper.

3. INTERACTIVITY – Bringing Life to History
While 3D scanning is widely used for the preservation and analysis of heritage, such as monitoring the possible deterioration of the Willandra Trackway site, the potential of this rapidly advancing 3D technology is yet to be fully identified and utilized in human experience and engagement. At this point the focus of these projects has been on raw data capture, yet there is a critical phase to come, a phase focussed on how we apply captured 3D data and better utilization of 3D reality capture and 3D modelling techniques to benefit the interpretation, analysis, delivery and display of heritage artefacts in order to facilitate human interaction for the provision of cultural understanding. Arguably tourism is an exceptional outlet to showcase the technology, offering visitors the opportunity to interact with 3D scanned items in mixed realities.
Interestingly this focus on interaction, engagement and user play, is, and has long been, at the heart of computer games design and development. The potential to apply technology based interaction techniques, including online interactions, games and VR/AR systems, to deliver access to these historical datasets for a broad audience is evident. From the earliest days of computer games and virtual reality, the ability to place the user in an artificial space built or modelled on real world history has been actively pursued. In fact the use of “iconic” historical sites is common in both early and modern computer games [18,19]. The ability for an immersive computer game, or VR environment, to place the user in an unreal, yet believable space is potentially a powerful tool to address the loss of our historic sites, and more importantly their stories.

Virtual archaeology and Virtual Heritage have evolved from two slightly different perspectives [20]. The first, based in information capture and presentation, involving obtaining, documenting and at the highest quality, recording and preserving the key information and data. In simple terms, this perspective involved acquiring and recording the artefacts accurately for future use. The second perspective, based in entertainment and distribution of knowledge, involved the development of interactive ways of enabling users to experience the history and while well documented and interpreted, digital presentation of the Willandra Trackway site remains underdeveloped.

4. CONCLUSIONS & DISCUSSION

Until recently the emphasis has been on the preservation and analysis of heritage artefacts and landmarks, but tourism products and experiences, particularly in regional destinations, also provide the potential to generate substantial social contribution to local communities (the Mungo Youth Project is an example of this) while also developing resources such as teaching aids and digital storybooks. Yet, significant challenges face heritage tourism destinations, including the preservation of artefacts, monuments, objects and landmarks and subsequent transition into viable tourism experiences.

3D reality capture (3D laser scanning) is a valuable piece in the preservation of historical knowledge. Yet, there is potential for 3D scanning to extend beyond accurate data capture to bring a level of realism and truth to a historically accurate digital model through virtual tourism experiences. Using 3D scanning, digital storytelling can be explored as a way of bringing these historical relics to life for a much larger audience. Virtual heritage and virtual museums are well established. However, developers are using 3D scan data as a template for remodelling these scenes for immersive realities. Quite often, the identity and realism from the artefact being scanned is lost, as the information is translated into a simplified copy of the original through a series of post-processing, mesh decimation and texture mapping workflows. This current process is extremely time consuming, reduces the accuracy of the scan data and increases the risk of human error. There is a need for systems that enable developers to more quickly obtain “real-world” items and environments. Thus, developers, researchers and museums alike need to look beyond 3D reality capture as only a method for preservation and better utilise the full scope and possibility that lies behind 3D scan data as a tool for interactive user experiences. Understandably, it is not possible to recreate the entire history of an object through 3D scanning. Therefore, archaeological and entertainment approaches need to be combined to reproduce the event and enable users to have a deeper level of engagement with the story behind the scanned artefact.

The aim of this research is to develop 3D scanning and post-processing workflows for Interactive Realities to provide people a truly accurate and realistic user experience with the Willandra trackway and the cultural heritage of the traditional owners of this land. Whether an archaeologist, cultural historian, a person seeking answers, or a visitor to Mungo National Park for the first time, it will allow people to involve themselves with Indigenous Australian history, culture and people to better understand and follow their stories.

While it is a privilege to work with the Three Traditional Tribal Groups on the Willandra trackway case study, it is the development of the workflows required for the preservation of artefacts and heritage sites, and the techniques involved with analysing and presenting this information that must be considered of special importance.

Methods for manipulation of large point-cloud data sets are still inadequate. Until this is properly addressed, communication and presentation of heritage items and iconic landmarks requiring measurement and detail accuracy cannot be achieved. The rapidly evolving technologies in Interactive Realities can provide 3D scanning for heritage preservation an opportunity to create a window into the past and present history in ways that users have never experienced before.

This is achieved through the development of the tools required to help people better engage with objects and their surrounding stories, to create new levels of emotion giving cold objects warmth and bringing them to life. There is concern that replications of heritage sites and objects, through scanning and technology, may reduce the significance or importance of monuments, as well as reduce visitors desire to visit the site or the museum. However, this project aims to communicate and share the historical objects and landmarks of the Willandra Lakes Region with a broader audience, and increase awareness of historically significant monuments. This data can be used to reproduce off site scale replicas of the site (such as the 3D printed replicas of trackway site mentioned earlier) and augmented reality experiences that enable people to walk with this family and bring their experience into the present. Thus, the research has the potential to attract greater interest in these sites and objects, encouraging an increased visitation to the site or museum.

There are some limitations and constraints associated with this research. One limitation is the level of realism that can be presented through AR/VR. Whilst every effort is made to create photorealistic 3D models of the sites and objects, the realism is limited to the available technology. The limitations of technology also create limitations for this research. As the integration of laser scanning and AR/VR is a new
area of research, challenges are evident for establishing the workflow to achieve this. However, leading experts in 3D reality capture will continue to be consulted to develop hardware and software workflows. Another limitation is the level of understanding which can be obtained from the ‘stories’ surrounding the artefact or heritage site. The research cannot fully depict an accurate representation of the history of each site or object, presenting an interpretive view of the past. Using multiple sources containing documented recounts of the history of the case study, every effort is made to remove subjectivity from the interpretation by only presenting factual information.

The research also provides direction for future developments using new technology. The workflow developed in this research can be further tested and applied for any heritage object or landmark. The high level of accuracy, reduced risk of human error, and non-intrusive approach that the workflow offers makes it suitable for a range of sites and monuments. Future 3D scanning using the workflow will encourage the preservation of objects, which can be viewed and analysed at any time, allowing for comparisons of the object over time. Future research should also encourage the development of a global network of information to engage archaeologists, palaeontologists, museum curators, and other researchers. Such a network can expand applications of 3D scanning for human experience and further contribute to the historic preservation of artefacts and the stories that bring them to life.

The trials we have implemented have shown the potential of the approach, the technologies and workflows needed to take a cold historic site and transform it into an interactive environment. There is clearly still much to do, and the project, which is currently only in the first phase will continue to expand and extend into this exciting field. The Willandra region is home to some of Australia and the world’s most valuable historic sites. It is clear that the stories held in this region offer powerful links to culture and history for many, yet they are currently completely hidden from view. This research project demonstrated techniques to allow the capture of the physical data and its conversion into workable real-time interactive systems. Bringing this workflow together with knowledge from archaeological studies and regional tribal knowledge will enable those stories to be told to a new and much broader audience.

REFERENCES