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# (Re)presenting heritage: laser scanning and 3D visualisations for cultural resilience and community engagement

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### Abstract

Cultural heritage is increasingly being viewed as an economic asset for geographic areas who aim to capitalise in the surge in interest in local history and heritage tourism from members of the public. Digital technologies have developed that facilitate new forms of engagement with heritage and allow local areas to showcase their history, potentially broadening interest to a wider audience, thus acting as a driver for cultural and economic resilience. The research presented in this paper explores this through interdisciplinary research utilising laser scanning and visualisation in combination with social research in Elgin. 3D data capture technologies were used to develop and test 3D data visualisations and protocols through which the urban built heritage can be digitally recorded. The main focus of this paper surrounds the application and perceptions of these technologies. Findings suggest that the primary driver for cultural heritage developments was economic (with an emphasis on tourism) but further benefits and key factors of community engagement, social learning and cultural resilience were also reported. Stakeholder engagement and partnership working, in particular, were identified as critical factors of success. The findings from the community engagement events demonstrate that laser scanning and visualisation provide a novel and engaging mechanism for co-producing heritage assets. There is a high level of public interest in such technologies and users who engaged with these models reported that they gained new perspectives (including spatial and temporal perspectives) on the built heritage of the area.

### Keywords

laser scanning; built heritage visualisation; local heritage; resilience; community engagement

## 1. Introduction

There has been a resurgence of interest in history and heritage amongst members of the public and a strong belief at local, national and European levels [1] that cultural heritage can be utilised as a mechanism for economic growth and resilience [2]. However, cultural assets are not distributed evenly and factors such as accessibility from main transport

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hubs mean that some locations are in a better position than others to capitalise on their cultural and heritage. The research presented in this paper is specifically focussed on the use of high-definition laser scanning and 3D visualisation of the built heritage. Initiatives involving laser scanning of heritage sites have become popular as evidenced by high profile projects such as The Scottish Ten [3] which is digitally documenting Scotland's five UNESCO-inscribed World Heritage Sites (WHS) and five international heritage sites to create a database of digital information on globally significant heritage sites. Conducting laser scanning of sites can be very costly and time consuming requiring specialist expensive equipment [4]. However, in recent years, laser scanners have been developed that are capable of scanning larger areas in less time and can produce high quality 3D visualisations through the use of widely available and useable software [5]. This has opened up new possibilities for researchers to work with local communities, digitally recording heritage sites that are locally significant but that may not meet the criteria for WHS, therefore tending to be overlooked in many high profile and high cost visualisation projects. Other projects have seen interesting technological developments including heritage visualisation mobile apps for smartphones that allow users to develop an understanding of heritage sites (for example, [6]). In addition to the potential applications for tourism, such initiatives have potential as education tools, for empowerment through co-production of local knowledge and to encourage community engagement in local history [7, 8].

This paper explores these issues through interdisciplinary research involving laser scanning and visualisation in combination with in-depth social research in Elgin, which is a historically significant small town in the Northeast of Scotland. The technical dimension to the research involved the use of 3D data capture technologies, to develop and test visualisations and protocols through which the urban built heritage can be digitally recorded. The key focus of this paper surrounds the application and perceptions of these technologies as a mechanism for public engagement with heritage. The objectives of the paper are: to critically analyse drivers and implications of the reuse of cultural built heritage from the perspective of heritage policy and strategies to preserve, recognise, promote and manage cultural heritage. A further objective is to evaluate how this can be supported through the use of laser scanning and interactive built environment visualisations in community engagement initiatives. Finally, we assess issues of usability, aesthetics, the inclusion of contextual data and sustainability.

## 2. Literature Review

### 2.1. Cultural Heritage Policy and Resilience

The Scottish Government has acknowledged the growing importance of the heritage sector in its arts and creative policy [9]. The policy links to a number of other key policy priorities including social inclusion, digital participation, lifelong learning, health and well-being. In 2012, Creative Scotland and Scottish Enterprise expanded upon the creative industry disciplines which were deemed relevant to the Scottish economy and society. This new Scottish definition (following on from comparable work undertaken by the Department of Culture, Media and Sport in London) sought to 'reflect the character of artistic, cultural and creative endeavour in Scotland, and its industrial structure not only as a whole, but within the country's various geographic areas' [10:1]. The definition now includes heritage (including, specifically, museums, galleries, archives, libraries and historic sites) as well as cultural education. It is important to note that connections between culture, heritage and economic benefit are unlikely to deliver their potential in the absence of a clear strategy and plan for implementation. Some communities are well equipped to demonstrate resilience in the face of changing conditions while others suffer fragmentation and loss of social capital. Local areas are in competition with one another for tourism and, in light of the importance of the industry, many local regions develop strategies around how best to showcase and promote the unique cultural heritage of an area.

Policymakers are under pressure to develop 'evidence based' policies and to demonstrate value, preferably through quantitative economic impacts. However, the focus on value purely terms of economic growth can lead to cultural heritage becoming commodified and viewed as assets of business [11]. This 'instrumentalisation of culture' perspective is also supported by Bianchini [12] [13] and Caust [14]. Furthermore, the value of cultural heritage is challenging to assess. Researchers argue that there are a 'myriad impacts of tangible and intangible cultural heritage on social capital. It points to significant potential of heritage in terms of providing places of encounters and community hubs, sites of social integration and inclusion, functioning as a source of identity and local pride as well as being a reason for common actions, activities of NGOs and volunteers.' [15]. According to Smith [16] there has traditionally been a dominating 'Authorised Heritage Discourse' that frames and underlies the practices within cultural heritage management which rests on elite social values and aesthetics, and is managed and reproduced by expert knowledge. There has been a recognition, however, that community perspectives and participation in cultural heritage are a key factor for enabling the

development of resilient communities by the construction of locally relevant cultural narratives whereby the future of communities is envisioned by understanding the past [17]. Norris et al [18] suggest that resilience may broadly be considered to be ‘a process linking a set of adaptive capacities to a positive trajectory of functioning and adaptation after a disturbance.’ A less systemic definition is provided by Horne [19: 27] who suggests that: ‘To varying degrees, resilience is a fundamental quality found in individuals, groups, organizations, and systems as a whole. It allows a positive response to significant change that disrupts the expected pattern of events without resulting in regressive/nonproductive behavior’. Institutions such as libraries and archives are considered to be ‘anchor institutions’ which contribute to the social, economic and cultural strength of an area and thereby contribute to local resilience [20]. Libraries are spaces where knowledge, including heritage, is created and shared and many are making use of collaborative and social technologies to encourage this [21].

## 2.2. Laser Scanning and 3D visualisation

Laser scanning projects are often conducted within the realm of digital conservation to preserve a record of vulnerable sites. For example, recording scientific data about sites for the purposes of technical conservation (e.g. condition monitoring), or facilitating new forms of public engagement with heritage [22, 23]. Where these have been applied within a built heritage context, specific challenges have been addressed, including those concerned with recording, 3D scanning [24], photogrammetry and adaption of data for incorporation within modelling techniques [25].

Recent technical advances in the fields of photogrammetry and online access to mapping data have meant that there appears to be an opportunity to democratise the processes involved in the creation of digital heritage assets. With regards to photogrammetry, the widespread availability of mobile applications supporting the creation of 3D surface models and point clouds from photographs has transformed the use of such techniques, and has moved these from being expert-driven methods [26] to approaches appropriate for community-wide usage [27]. Relatively recent developments, including the use of cloud-based photogrammetry (e.g. Autodesk Memento and 123D catch), have meant that the technical distance between results obtained using professional laser scanning equipment and the collection of heritage object data using financially accessible methods (including mobile consumer devices), has narrowed considerably. This suggests in turn the possibility of undertaking studies where the collection of heritage digital objects has been crowd-based, with guidance (but a lessening of control) by the expert.

Cultural heritage manifests tangible materialities as well as cultural meaning, social and individual perceptions and experiences and intersubjective emotional affect, just as the urban identity to which it creates and belongs (including notions of social sustainability in a heritage context [28]). This suggests an approach to the subject where metadata-rich models would extend the data typologies suggested by Styliadis et al [29], which have much in common with physically-oriented building information models, to incorporate qualitative and socially-driven information. Cultural assets can exist across a spectrum from ‘high culture’, recognised and protected in most regions, with cultural historical significance to that of vernacular or industrial structures, which can equally provide insights into the societies and culture from which they emerged and in which they are part of the ongoing development of place specific cultural urban identities as basis for cohesion and communities [30].

The nature and purpose of laser scanning means that it captures precise geometrical detail of the physical environment, which can be used to support the creation of representative 3D models of a given space, or objects. The resultant data set includes various abstracted digital records of places and objects, including information contained in a ‘point cloud’ (representing physical surfaces) and photographic information pertaining to the visual appearance of an area at the time of scanning. Such data is then capable of being manipulated for incorporation in further design work (including architectural design, or 3D printing), or can be viewed and interacted with online by the non-expert with early work reported by Guarnieri et al [31].

Research has shown that the subjective interpretation of these virtual spaces is as varied as people’s experience of navigating actual physical spaces, suggesting that the models represent is (in some respects) a valid surrogate for the actual environment [32]. However, in order to make sense of the models on a cultural or emotional level, it is likely that users will require virtual environments that are not just visually and spatially convincing, but must also have relevant contextual information [33]. 3D virtual environments representing built environment heritage are highly dynamic. Additional contextual information can be embedded in the visualisations and they provide ideal bases for gamification and the development of learning tools. Providing mechanisms through which local users can participate and engage with resources allows for a greater diversity of perspectives and interpretations of community heritage to be represented [34] [35] and to enhance knowledge and understanding through the integration of user generated content such as crowdsourcing of content, ‘tagging’ and commenting on digital artefacts [36]. Previous research has determined that communities believe that digital cultural heritage can be a driver for economic growth by encouraging tourism, but the

relationship between the use and reuse of cultural heritage and community resilience is complex and requires further investigation.

### 3. Methodology

The paper draws on findings from an on-going programme of research activities conducted in Elgin in the North-East of Scotland, which has a rich cultural heritage but, like many areas, is facing economic challenges. In March 2014, a portable laser scanner was used to capture a 3D scan of Elgin Ladyhill/Castle. Following this, a community engagement event was held in Elgin library involving 16 participants where user evaluation and informal interviews were conducted. This phase of research had two main objectives: to develop and test protocols for capturing and visualising built heritage data and to gather data from members of the public about their opinions on the technologies including usability issues of navigating and interacting with the scans on laptops and tablet devices. In the course of the research the project team also discovered that interesting developments were being planned in the local area, specifically the Castle to Cathedral to Cashmere project which has a strong emphasis on digital technologies and will be discussed in the findings section of the paper.

The project team were subsequently awarded a larger grant which enabled more extensive laser scanning and social research to be conducted. A series of 12 interviews were conducted by telephone in November 2014. The interviews were mainly drawn from the partnership group of the Castle to Cathedral to Cashmere project and included a diverse range of local stakeholders including: local and regional economic development institutions, local heritage groups, representatives from the business community and the library. These interviews were conducted to determine the strategic perspectives and motivations for local communities to undertake heritage projects and explored themes such as economic development, tourism and cultural resilience. The interviews were particularly focused on the opportunities and challenges of using digital technologies such as laser scanning and visualisation in local heritage initiatives. Interviews were recorded and transcribed before being analysed using an inductive qualitative 'framework' analysis approach to identify key themes.

Following the interviews, a series of participative community engagement activities were designed and undertaken in order to evaluate the use of laser scanning and visualisations for public participation with built heritage initiatives. A community laser scanning workshop was conducted at the historic High Street/Little Cross area involving 20 members of the public and included a talk from a heritage expert in the library followed by demonstrations of 3D scanning and visualisation and group discussions. The objective of this workshop was to evaluate the direct involvement of users in laser scanning and visualisation and the added value of local heritage expertise in levels of user engagement. Participant observation was conducted over the course of the workshop by two researchers who took notes and facilitated discussion throughout the day.

The scan data was combined with a further eight laser scans and was developed into an interactive 'townscape' using the Leica TruView, which facilitates the process for viewing HTML visualisations. In the next user engagement activity at the library, six users participated in individual sessions lasting around 45 minutes each where they navigated the townscape visualisations and provided commentary and feedback. The screen captures and comments were recorded using Camtasia and the videos used for subsequent qualitative thematic analysis. These sessions had two main goals: to gain feedback about usability and additional functionality that they thought would enhance the experience and participants were also asked to draw attention to areas that they found particularly interesting. The feedback from this event led to a further development of a 3D environment. Potree (a free point cloud viewer tool) was used to create a 3D model with additional contextual information and the navigation and visualisations were improved. In the final user engagement event, a walking tour of historic sites of Elgin was conducted followed by a focus group with ten representatives from the Castle to Cathedral to Cashmere working group and four external consultants who had been appointed to work on the next phase of the project. The objective of this session was to gain user feedback on the latest heritage model with enhanced usability and additional information. This focus group was not recorded by notes were taken by the two researchers in attendance and these were analysed and synthesised with other the other strands of data collection and findings are presented in the following sections.

## 4. Findings and Discussion

### 4.1. Cultural Heritage Strategy and Resilience

Interviewees discussed the value of cultural heritage to the area and the local strategies and initiatives that were being undertaken in Elgin and the wider Moray area. Tourism (with a focus on heritage tourism) became a strategic priority for the area following the announcement of the closure of a local Royal Air Force base and a recognition that the impact of online shopping was resulting in challenges for retail in the town centre which was experiencing declining visitor numbers and closure of retail spaces. The main priority highlighted by interviewees was to encourage more visitors to the area, for them to stay longer, to visit more areas of the town centre and, ultimately, to spend more money during their visits. It was reported that in 2013 the value of tourism in Moray and Speyside was £95 million which represents 1.7 million visitor days. Growth of culture and heritage were highlighted as priorities by interviewees and also reflected in the Moray Economic Strategy.

Interviewees expressed a view that Elgin had challenges related to its geographical location (in that visitors may often travel through Elgin on the way to the highlands rather than see it as a destination in its own right) and that heritage sites in the town and locale tend to be dispersed rather than in a clear 'trail', which visitors could follow. There was also felt to be an absence of a distinct local heritage 'narrative'. A further barrier to the development of cultural heritage tourism mentioned by interviewees was a lack of co-ordination.

We've got a very fragmented tourism offer and as part of that we've got a very fragmented heritage offer. In some ways the way that we organise ourselves compounds that... So we can end up operating in siloes. [Interview 3].

There were also concerns regarding the ageing population of the area, which was believed to be a threat to the resilience of cultural heritage in the area because important local knowledge was at risk of being lost:

You've got certain things that happen and as oldies start getting old, and our predecessors who are getting frail and their memories are not very good, you've got that tendency of actually things happening and losing that connection, the bond going forward... it's also trying to make it interesting for people to come to visit Elgin, to actually say "what is Elgin? What is its ethos?" [Interview 4]

The main heritage-specific project discussed by interviewees was the Castle to Cathedral to Cashmere initiative which, at the time of the interviews in late 2014 was in the process of applying for funding and started in May 2015. The project involves a range of activities to overcome some of the challenges mentioned earlier including: funding to improve the physical heritage sites and signposting as well as an extensive programme of public engagement activities and the development of digital tools including websites, interactive visualisations and historical interpretation. A further aim of the initiative is to develop a more cohesive presentation of the history and heritage of the area from the ancient ruins of Elgin Castle and Cathedral through to the more recent history, with the Cashmere element referring to Johnsons of Elgin, a world-famous textiles firm that attracts a large number of visitors. Interviewees indicated that very few visitors go further into the high street to see other sites of historical interest. A diverse range of stakeholders are involved with the Castle to Cathedral to Cashmere project which can be seen as positive in terms of cultural resilience by enabling a plurality of views to be expressed. However, interviewees were candid that it meant that the scope and remit of the project took a long time to be agreed and that there were differing views on what constituted heritage and how this should best be presented. For example, one respondent discussed striking a balance between focusing on grand families of the area or whether the heritage activities should be focused on the lives of more ordinary people. This suggests that resilient cultural heritage is in a process of constant reinvention and negotiation, and is not static.

### 4.2. Digital Technologies for cultural engagement

Interviewees discussed the potential for digital technologies to enhance the tourism experience of the area, both by encouraging people to come to the area with online exhibits and promotional activities, and also by using technologies in interactive exhibits and digital tourism trails which could provide visitors with additional information on areas of local significance. The perceived benefits of these technologies, such as laser scanning and 3D visualisation were discussed by the interviewees and an interesting finding was that respondents viewed the very fact that advanced technologies such as laser scanning was being utilised was adding value to the built environment heritage by providing a 'wow factor' that could set Elgin apart from other areas. Additional value was viewed as being the ability not to simply capture the sites but to enable people to engage more fully with the story and signpost them to places of interest:

My impression is it doesn't just capture a moment in time, it captures a series of moments through time and brings them alive in a literally three-dimensional way so that one could look at presenting the story and encouraging research or an inquiring mind in a more dynamic way into the past... I suppose we're looking at the past, but it's looking at the past with an eye on the future and how the past can be better understood and the strengths of it better incorporated within the future development of the town. [Interview 1]

Interviewees also viewed digital technologies as mechanisms for connecting people to place and for connecting the past to the present. Several respondents commented that community engagement events could be developed with young people at the local high school and college where they could directly participate in the creation of digital resources e.g. through collaborative programme events known as hackathons. Technologies such as augmented and virtual reality were viewed as being mechanisms for doing this as there is the potential for removing modern buildings to show how a street looked in the past. For example, Elgin Castle was destroyed by Robert the Bruce in 1308 - no visible ruins remain and nobody knows what the castle really looked like but scanning and visualisation technologies could be used to help facilitate artistic impressions. Further, the ability to integrate additional contextual data, voiceovers and user-generated content with scans and digital townscapes was viewed as being the main appeal in order to develop a rich picture of the heritage and culture of the area.

What I feel is critical is making the link between what you can see today and what was there in the past. And I just feel that this takes it a step further. Now, from our own point of view, we're a small amateur, entirely volunteer-run heritage group, and our remit is to research and conserve the heritage, but also importantly to share it with other people... I think our organisation would benefit because it would help us to do our job better, but also it would be appreciated by whoever's looking at it. [Interview 12]

Interviewees also commented that the digital tools could be linked with 'offline' activities such as performances by the local theatre company. Further, interviewees also indicated that interactive 3D models could also point visitors to local shops and businesses:

You could have somebody looking at a historical document or information on an iPad or a smartphone and at the same time they might get a link to "oh, you must go shopping to WH Smiths" or "got to Café Cross for your coffee" or something... It's not just about "here is the tourist information, enjoy history." It's about how you plan your whole your day and transport and going back to your accommodation, you can do a lot of that stuff electronically. [Interview 11]

Interviewees were very positive about the potential for digital technologies for local cultural heritage but were not clear on exactly how the positive effects would be realised or which tools in particular should be utilised. The series of community engagement activities were designed to explore these issues further. The library was selected as a venue for running a series of user engagement events for the project as Elgin library was the location of the tourism information point and had extensive local history collections. The events were developed and delivered in partnership with library staff who assisted with providing spaces, staff support and assisting with promotion and marketing of the activities. Findings from these community engagement workshops will be presented in the next section of the paper.

### *4.3. Pilot Scanning and Visualisation of Elgin Ladyhill.*

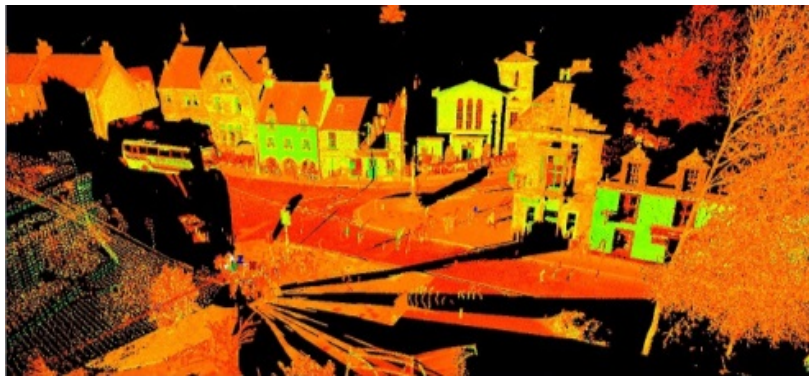
The first community engagement event followed the laser scanning of the historic Ladyhill site. These are important local landmarks; the ruins of Elgin castle date back to the 12th century and stand at one end of the Royal Burgh High Street. A Leica C10 laser scanner was used which offers the ability to record the point cloud and also take photographs that the supplied Cyclone software can incorporate into the visualisations that it creates. Members of the public were presented with visualisations and 'fly-through' video captures of the laser scan data. They were also able to view and interact with the visualisations on tablets and participated in short informal interviews about their views of the technologies. Participants commented that the scan of Ladyhill enabled them to literally 'see it in a new way' by viewing Elgin from different perspectives. Despite recognising the historical significance of the area, many participants commented that they had either never been to the top of Ladyhill or had not done so in years and therefore viewing the site from these angles was a different experience for them. A commonly recurring theme was that participants commented that that they were thought that the area looked better or 'more romantic' on the scans than it did in reality.

Several participants commented that this was an area that they 'took for granted' because it was a familiar landmark and that having viewed it on the scans they would then go and pay more attention to Elgin Ladyhill/Castle when they were passing it. An interesting and unexpected finding was the level of interest that the participants had in the technical aspects of the scanning. One participant commented that the laser scan visualisations were like those that they had seen

on television shows such as 'Time Team'. Participants asked a number of questions about the functionality of the scanner, the advantages of laser scans over photography, the integration of the photographs, and the time taken to make the 3D models. The level of public interest fed into the development of subsequent project activities.

#### 4.4. Community laser scanning workshop

The second engagement activity, a community laser scanning event, was conducted as a participative workshop in the library to further investigate how laser scanning can be used to enable community engagement in heritage. In order to fully integrate local expertise, the event involved a local historian and author who gave a presentation about the scan area at Little Cross (located at the East end of Elgin High Street) which included stories and old photographs of the area. The presenter drew attention to areas of architectural and historical significance for the participants to look out for during the scanning demonstration. Following this presentation, around 20 people came to Little Cross to view the demonstration. The researchers described how the scanner works while running a scan of the area, and responded to the questions raised by participants. A high definition scan was selected along with photographic images of the same area. It was found that the developments in scanning technologies made them more suitable than previous generations of scanners because of the speed that scan data can be captured, it was easier for participants to see how the scanner worked on site (including a display on the scanner itself) and improvements in the software meant that it was faster to create visualisations of the data so that participants could view the outputs. On return to the library the scan data was downloaded from the scanner and imported into Cyclone and the visualisations were presented to the audience (Figure 1). A question and answer session followed with the audience showing a keen interest in both local heritage and the ways in which scanning and visualisation technologies could be used to showcase this.



**Figure 1.** Visualisation from Laser Scan of Little Cross.

The community laser scanning workshop demonstrated that libraries are not simply heritage repositories but also spaces for facilitating public engagement with heritage. An important factor to consider is the strength of the partnership approach of bringing together academics, local experts, community participants and librarians which enabled the innovative engagement activity. The novel approach of utilising the laser scanner as a way of facilitating community engagement proved to be successful by acting as an enabling mechanism for in depth discussions of heritage as well as providing a technical 'hook' which was a key point of interest for participants.

#### 4.5. 3D visualisations for remembering Elgin's Past

In early January 2015 the researchers returned to Elgin to conduct additional scanning of Elgin High Street.





**Figure 2.** Map of Elgin High Street. © Crown Copyright and Database Right 2015. Ordnance Survey (Digimap Licence)

Starting at Little Cross (shown in Figure 2), the researchers were able to perform 8 scans, reaching beyond St Giles Church in the pedestrianised section of the High Street. From a technical perspective, it was interesting to note that the scanner was at times required to operate in inclement weather conditions of snow and rain, with some scans exhibiting significant ‘noise’ in the dataset (due to the laser recording snowflakes, rather than the intended buildings). On return to Aberdeen, the researchers used the registration function of the Cyclone software to combine and ‘unify’ the various scans, thus creating a single continuous point cloud of the whole of the High Street (see Figure 3). The number of points in this image is in excess of 100 million, and the file size is several gigabytes.



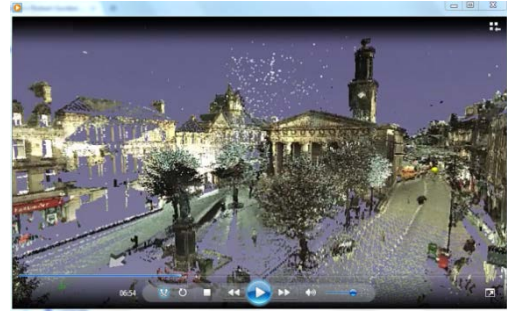
**Figure 3.** Elevation view of Elgin High street scan

It was decided to use Leica TruView process for viewing HTML visualisations. This requires the point cloud to be processed by the Cyclone PUBLISHER module, which converts the data into HTML format for web viewing through the TruView panoramic point cloud viewer. For the purposes of this study, the Truview environment contained two main views: a plan view, and the fly-through itself. The plan view (see Figure 4) shows a top down view of the visualisation, with the locations at which scans were made marked by yellow triangles. These can be double clicked to take the viewer into the 3D visualisation at that point.

At the subsequent user engagement event with the interactive visualization each participant was given a brief demonstration of how to control the fly-through (Figures 4 and 5) and then they were free to navigate the scan and identify features of interest. The degree of comfort with using the mouse to interact with the visualisation varied from person to person, with some quickly becoming adept (particularly one user who was already familiar with electronic gaming) while others remained more tentative throughout the process. Despite this, all users were able to navigate their way along the High Street and switch between different scanning points, with occasional assistance from the researchers.



**Figure 4.** Scan sites in Plan View



**Figure 5.** Screenshot from Fly-Through

Several points were revealed by the actions and comments of the participants. Firstly, they were all interested in the way that the townscapes worked, and the range of views and perspectives this gave them of the High Street. For example, one participant commented:

You've picked up the buddleia in the gutters- that's beautiful. You've got more rooftop data than I'd imagine actually.  
[participant 5]

The user engagement event was designed as an unstructured session so the researchers could evaluate issues of participant interest. In addition, they were also encouraged to share their personal memories of Elgin and to navigate to historical sites on the visualisation that they thought were particularly significant. It was interesting that, even with a small sample group, each person found something different in the fly-through that was of particular interest to them. For example, one participant navigated the scan and zoomed in to a small area of a building to draw our attention to historic dates stones. Another participant had a particular interest in a milestone marking the centre of Elgin, having identified the stone on the scan he discussed why it was locally significant and requested that it should be annotated in future visualisations. More contemporary features were also discussed by participants, such as Christmas lights. One of the participants was a local businessman who showed us the location of his shop on the model. While participants were mostly positive about the quality of the visualisation, one participant drew attention to the preponderance of signs indicating business properties for sale or let (which she described as 'depressing' and felt gave a poor impression of the town), and several commented that the signs seemed more prominent in the visualisation than in reality and asked if they could be removed. This echoes previous findings from the interviews which reveal that local people are concerned about how the area is portrayed to external audiences.

Participants in the third user engagement workshop reported that the 3D visualisations would be enhanced by adding additional navigation to show where they were in the scan, options to 'walk' as well as to fly through the scans and, crucially, by incorporating additional contextual information about the history and heritage of the area. The general feeling was that viewing and navigating the fly-through visualisations was interesting but would not be sufficient to engage users:

For me this experience is interesting, but would I do it again, would I do it often? I'm maybe not getting enough out of it...  
[participant 4].

The 3D visualisations can be enhanced with additional contextual information to include photographs, video and audio, and links to digital artefacts hosted on other websites. Participants were also requested to bring along historical artefacts from the local area to discuss while viewing the visualisations, and also so that these could be digitised and incorporated into the visualisation to provide additional contextual information. One participant brought an album of historic postcards which included several views of buildings in Elgin that no longer exist (such as the town hall that was demolished in 1939), and one brought a display of characters from the town's past and a series of prints showing the 1500 year history of the Laich of Moray, once a sea loch to the north of Elgin providing a thriving medieval harbour that silted up and was drained in order to provide agricultural land. Many participants suggested that techniques such as gamification and augmented reality would provide a more engaging experience for users and to enhance their understanding of the history and heritage of the area:

... in their minds they are not finding out about a place, they're just finding out about specific things rather than a wider story and that's one of the big benefits of this to my mind. It's creating that narrative that embraces a number of different sites, a number of different storytellers within an overall single narrative or multiple narratives that move people around within that. [participant 3]

One participant suggested that a 'treasure hunt' style game could be developed where users could travel around Elgin and find historic sites and information. A further participant noted that providing historical information on the scans would enhance tourists' knowledge about the area as many visitors are not aware that they were visiting a town that dated back to medieval times and are 'blind to the architecture'. All respondents commented that the incorporation of old photographs, artistic impressions and historical information would enhance the visualisations. For example, one commented:

I was wondering if you could do, not a full reconstruction of Elgin High street in different periods, but if you could hover over where the town hall was and it could bring up a photograph.' [participant 1]

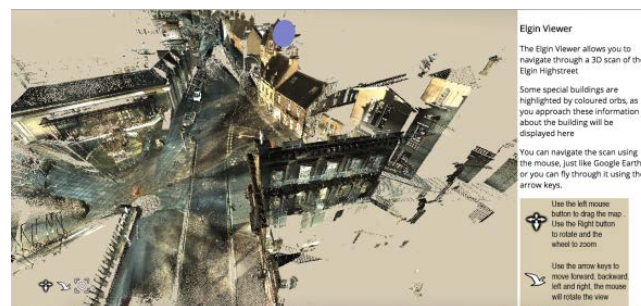
Participants also shared ideas about incorporating historical characters (such as Macbeth) as guides or narrators into the scan and believed that this would be particularly appealing to children and young people and that the visualisations could be used for education as well as tourism purposes. Several participants suggested adding in the functionality to incorporate crowdsourced information about local heritage into the visualisations but were aware that this would require moderation and mediating of content. Participants also indicated that they would like the functionality to be able to 'see inside' buildings such as the museum and churches to give visitors an idea about what is inside on days where the buildings were not open.

I was looking at St Giles church there.. it would be very interesting if you had a complete building, say for example St Giles Church and you were able to, even if the public couldn't get in on a particular day if you were able to see the inside, walk through the door and see the inside then come back out again. At least you would know what was there. [participant 2]

It was also suggested that future 3D visualisations could link to content held elsewhere such as information on the Historic Scotland website or that information about historical artefacts in the library or museum collection could be digitised and incorporated.

#### 4.6. 3D visualisations with added contextual data

Data from the third engagement event informed the final interactive visualization developed for the project using 'Potree' (Figure 6), where areas of interest were marked and incorporated additional contextual information and photographs of these sites when they approached a marker in the model. The visualizations were also presented in a more stylized rather than photorealistic manner which reduced the dominance of the newer buildings. A further advantage of Potree is that it is an open source technology, unlike Autodesk ReCap or Leica Cyclone which are financially expensive for non-educational users. Potree uses WebGL for rendering 3D point cloud data and allows for very large point cloud data files to be viewed in compatible browsers. This was particularly useful for the integrated high street scan data which was a very large data file.



**Figure 6.** Screenshot of Elgin Viewer

This model was demonstrated at the final user engagement workshop which was conducted in parallel with the launch of the Castle to Cathedral to Cashmere project. The event commenced with a walking tour of Elgin town centre

where historical sites were visited and discussed. Following this, an informal focus group was held where participants viewed and discussed the 3D model developed in Potree and discussed future developments for the Castle to Cathedral to Cashmere project. The added navigation and information was viewed positively by respondents who felt that the usability and 'look and feel' of the model had been improved. This was a more technically knowledgeable audience than had been present at previous user engagement workshops, and discussions quickly turned to the technical dimensions of the work such as the scanning outputs and specific file formats. For example, participants wanted to ensure that the scanning outputs were HTML 5 compliant. Further, protocols for integrating the research teams' scanning work with planned IT work being conducted by external consultants was discussed.

The added contextual information was also viewed positively by participants. One focus group participant had also been a part of the third user engagement event and reported that the additional historic information made him want to view the visualisation again whereas he would have felt less inclined to view the 'fly-through' data again without additional information. Information for future developments in the visualisations will be obtained from another group of external consultants who have been contracted to work on historical interpretation for the Castle to Cathedral to Cashmere project as well as from other local and national heritage organisations.

Participants also discussed limitations and potential challenges with digital technologies for heritage engagement. For example, the restrictions and pressures on the local authorities' IT departments was raised as a challenge whereby the strict rules on IT policies and procurement mean that there can be lengthy delays to local initiatives. It was also recognized that technologies change and develop very rapidly and therefore a range of technologies should be utilised including web and mobile applications compatible across multiple platforms in order to 'future proof' developments and facilitate the sustainability of the initiatives. These sentiments had also been previously reflected in the initial stakeholder interviews:

I think the biggest problem is really trying to future-proof it. And that's in the way that in years down the road you can actually still have access, use what there is. There's always that big question mark in the public sector with more and more constraints where we still have the staff resources around also to maintain and update any of the information. [interview 8]

It was also noted that familiarity with digital technologies is not ubiquitous, and that potential users may not have smartphones or similar devices. Therefore digital and online resources should be utilised within a wider programme of public engagement activities that may include non-digital activities such as historical re-enactments and physical exhibitions in the museum, library and other public spaces.

Following this user engagement workshop the project team have captured high definition scans of 20 heritage sites identified by the partnership board. These are currently being rendered into surface models using 3D modelling software and will be used in the development of interactive heritage websites and applications for heritage engagement and tourism. Other planned developments are to investigate options for 3D printing of heritage models and the use of game engines such as Unity 3D as well as developing mechanisms for the direct integration of user-generated content and links to social media. Further social research and community engagement activities are planned including collaborative scanning and programming with local schools and the college.

## 5. Conclusion

The findings from the primary social research addressed a range of research objectives. Firstly, the motivations and values of heritage stakeholders to engage in digital cultural heritage initiatives were evaluated. The research identified the primary driver for cultural heritage developments to be economic (with an emphasis on tourism) and there was a strong view that Elgin was not fully capitalising on its heritage assets. While this is indicative of an 'instrumentalisation of culture' approach [12-14], the respondents also indicated that digital technologies served a role of community engagement and participation in heritage to record and preserve local heritage which was viewed as being at risk. Further benefits of community cohesion and social learning were also reported and the strengthening of the connections between people and built environment heritage which are also key factors in resilience as understood in the literature [17-19]. Also in keeping with previous research, it was found that stakeholder engagement and partnership working were identified as critical factors of success and libraries and other memory institutions were identified as spaces where collaborative activities could be undertaken and act as 'anchor institutions' to strengthen local resilience [20]. The partnership approach enables innovative community engagement events utilising academic expertise and local heritage stakeholders including the library and heritage experts. This allows for a more inclusive and democratic approach to cultural heritage but may bring challenges of managing expectations and differing viewpoints. An interesting additional finding from our research was that interviewees expressed the view that utilising innovative digital heritage technologies

such as laser scanning and visualisations could have a positive impact on public perceptions of the built heritage by adding a degree of novelty to the heritage offerings of the area.

A further research objective was to evaluate the use of 3D laser scanning and visualisation technologies as mechanisms for community engagement with heritage. We found that technologies to support data capture, such as scanning and photogrammetry, have developed significantly in recent years, and that newer laser scanners offer the ability to capture larger areas in less time, and at a higher resolution than was previously the case. There have also been developments to assist with the transformation of that data into forms which can be useful to local authorities, heritage organisation, tourists and members of the community [23, 24, 28]. The research makes contributions to the field of heritage-led community engagement and resilience in a number of respects. Firstly, technologies can be utilised as community engagement initiatives with the technology in itself facilitating involvement of the user directly in the production of heritage assets. Secondly, interactive 3D models and visualisations were found to be effective mechanisms for promoting discussion and dialogues around heritage. Users who engaged with the 3D models experienced (often literally) new perspectives on the history and stories of areas by viewing their familiar local heritage in a novel way. An interesting finding was the heterogeneity of the experiences of users. A diversity of stories and observations were made from the fly-throughs showing that interpretation is influenced by prior knowledge, areas of interest and affective experiences of using the technologies. These findings suggest that heritage narratives are dynamic and evolve over time, which will be investigated further in future work. Finally, the incorporation of contextual data and information about the history and heritage of an area provides added value for users to gain additional understanding of local heritage.

This research presented in this paper has extended and juxtaposed previously disparate lines of enquiry, thus developing novel methods and findings concerning user-centred heritage modelling, heritage-led community engagement, and the use of interactive digital heritage by non-experts. The work is ultimately of greatest value in that it has demonstrated a methodology through which technical and social aspects of heritage studies can be used in combination to provide new insights and understanding. The technical/social mixed-methods approach is worthy of further exploration, particularly as it brings insights to the study of heritage through the application of techniques from information science (including crowd-sourced information creation and curation) in a context which has to date been unusual. It can also be noted that much of the research concerning laser scanning has been deeply technical in nature, and has focussed on technical solutions (including semi-automated translation of laser scanned data to building information models, or BIM). Other recently reported research [37] has explored the generation of 3D digital archaeological models through non-expert participation demonstrating that the technological basis for such work is now established to a point that it can be reliably incorporated in future work as a core method as opposed to as an exploratory enterprise in itself.

Likewise, much of the literature dealing with social aspects of the built heritage has tended towards the use of qualitative and humanities driven research (often exploring the important implications of digital work for institutional behaviour in the heritage field, such as in the work of van Heur [38]), whereas the study reported here used ICT and scanning as an approach through which participants can engage with the subject matter, without being experts in either the digital technologies or the engagement theories underpinning the work. This aspect of the work, the deliberate combination of applying cutting edge 3D scanning technology with bottom up approaches to heritage study is likely to produce insights regarding the ways in which we value and regard heritage, and is worthy of deeper investigation. Thus, the research suggests further work, whereby emerging technologies can be used as an invitation for widespread participation in the study of built heritage. The methodology also suggests connections with social history, and support for the generation of culturally and technically data-rich digital models (including heritage-BIM) using low tech, accessible software. Thus, the approach described in this paper holds real potential to democratise and widen participation in heritage studies.

The 3D visualisations of the point cloud data provided a vehicle for engagement and discussion around the scanned environment. The examples in this paper mainly used a 3rd person viewpoint, with the user flying through or over the environment. There are numerous emerging virtual reality and augmented reality technologies, such as the Oculus Rift and Samsung GEARVR could have the potential to vastly increase this level of interaction by immersing the user in the environment. In particular the Google Cardboard Project offers a low cost, open source immersion technology using consumer mobile devices. Further research in this area is needed to determine if the large amounts of data held in the point clouds is comprehensible in an immersive environment and what impact this has on the user engagement. The suggested path for future research, embracing the value of cross-disciplinary collaboration, is compelling. The mixed-methods and multidisciplinary core of that research is valuable, and holds potential to develop both theoretically and practically valuable outputs.

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