BradPhys to BradViz!

or

From Archaeological Science to Heritage Science?

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Abstract
Archaeology is a broad church and its role as a "two culture" discipline is frequently cited. This position at the interface of the arts and sciences remains central to archaeological activity but there have been significant changes in the structure of archaeology and its relationship to society overall. The growth of heritage science, in particular, is driving change and development within archaeology at a national and international level. This paper discusses these developments in relation to the author's own research trajectory and discusses the significance of such change
Key

During 2016 the University of Bradford, in the United Kingdom, commemorated the 50th year of its founding by opened a time capsule that had been sealed on the 12th April 1991[1]. As part of the University's celebrations the unveiling of the capsule's contents was clearly an important occasion and such commemorative events are of passing interest to many people. The contents of Bradford's capsule, which included a floppy disk and mobile phone, clearly indicated the direction of travel by society over the following decades and the inclusion of a calculator and coil conductor symbolised Bradford's position as an aspirational technology university. For the purpose of this paper one of the more interesting objects contained within the capsule was a pipe. The pipe in question had been the property of Harold Wilson (1916-1995), Prime Minister of the United Kingdom (1964 to 1970 and 1974 to 1976), and founding Chancellor of the University of Bradford from 1966 to 1985[2].

Several points spring from what may be, for many, a surprise inclusion within the capsule. For those who lived in Britain during this period Wilson, as a public figure, was defined almost as much by his omnipresent pipe as anything else and it was always there in cartoons and caricatures and frequently appeared larger than life. The next point is that Wilson, who led Britain through the momentous social and economic changes of the 60s, was convinced the technological change was likely to drive social development within Britain and the world. As a consequence, he became associated with a phrase "*the white heat of the technological revolution*" which came to symbolise his view on future progress. Whilst it is not certain that Wilson actually used this phrase initially, in a landmark speech in 1963 he asserted that "*We are re-stating our Socialism in terms of the scientific revolution. But that revolution cannot become a reality unless we are prepared to make far-reaching changes in economic and social attitudes which permeate our whole system of society. The Britain that is going to be forged in the white heat of this revolution will be no place for restrictive practices or for outdated methods on either side of industry*" (figure 1). From that statement it seems

reasonable to assert that the sentiment of the quote reflected Wilson's beliefs, and it is certain that he tried to act accordingly. He was, for instance, involved with creating novel educational institutions on that basis. This included the British "Open University" – an innovative distance learning and research university, and now one of the biggest universities in the UK and indeed the world[3]. Around the same time Wilson also founded the University of Bradford a technological, research university and later became its first Chancellor [4].

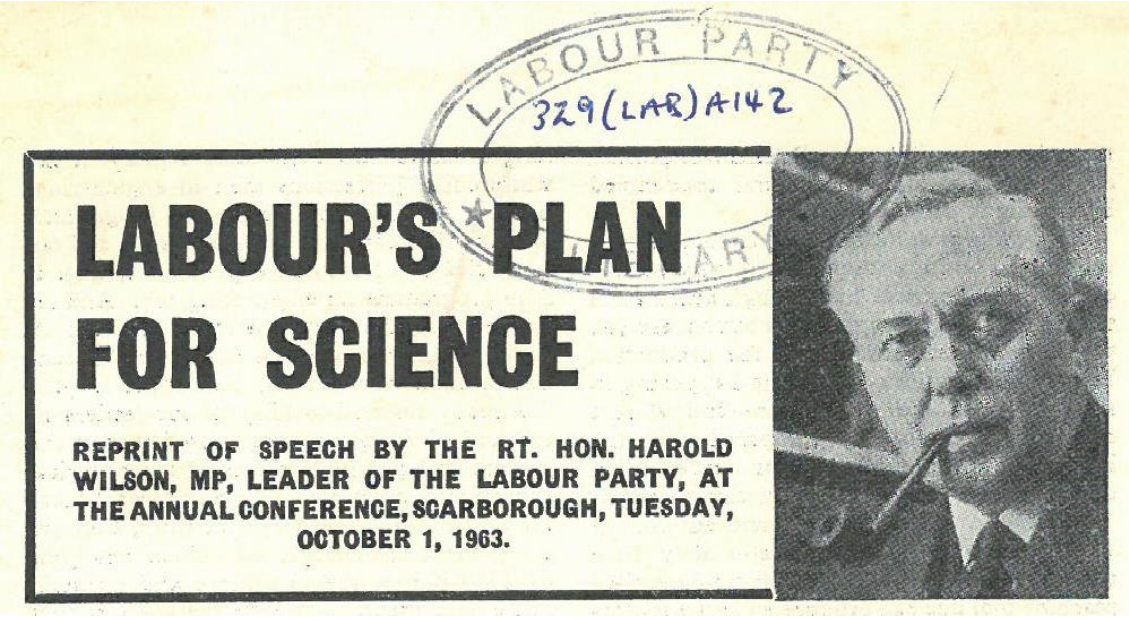


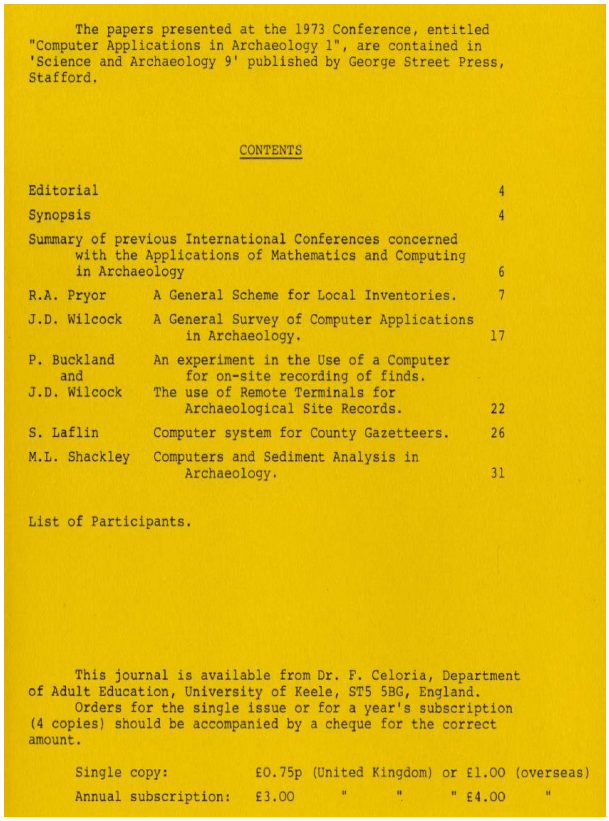
Figure 1 Harold Wilson's Plan for Science 1963 (The Labour Party)

The final point that arises from Harold Wilson's pipe is that, after its recovery, the very first act of the University was to request that the pipe was recreated as a 3D object by Bradford Visualisation, the digital research centre within the School of Archaeological Sciences[5]. The transformation of a heritage object, albeit as mundane as a pipe, into digital imagery, is in retrospect, a profound act for a number of reasons. Some of these, at least, are related to the development of archaeology as a research discipline and, specifically, the manner in which archaeology has developed at Bradford itself.

Figure 2 Ceci n'est pas un pipe – with due reference to René Magritte's work " The Treachery of Images" (Bradford Visualisation **https://sketchfab.com/models/e092a63a10234b8eac8ac99e4cfec1e8)**

To place this in context, the School of Archaeological Sciences at Bradford had very specific origins in comparison to most contemporary archaeological departments within the UK[6]. It developed initially, from a postgraduate archaeometry research group within Nuclear Physics and, not surprisingly, established a reputation in neutron activation and geophysics under the leadership of Dr Arnold Aspinall[7]. Although with strong research themes in material sciences and osteoarchaeology, remote sensing and particularly geophysics became synonymous with the early department at Bradford and the Bradphys, featured in the title of this article, refers to the BradPhys Resistance meter designed in the emergent department in 1970. This machine design formed the basis for commercial exploitation of the technology by Dr Roger Walker as the Geoscan RM4 meter -the workhorse of archaeological geophysics throughout the 1980s[8]

Archaeology, of course, had always existed as a "two culture" discipline but it is notable that parallel developments were occurring elsewhere, and in Birmingham and Staffordshire universities within the UK, two computer scientists, Dr John Wilcock and Dr Sue Laflin, founded the Computer Applications in Archaeology Conference in 1973 (figure 3). The second annual meeting of which was published as a standalone, albeit, slim volume and which formed the basis of the current international conference and volume series. The Journal of Archaeological Science, it may be noted, was also founded in 1974[9].



The papers presented at the 1973 Conference, entitled "Computer Applications in Archaeology 1", are contained in 'Science and Archaeology 9' published by George Street Press, Stafford.

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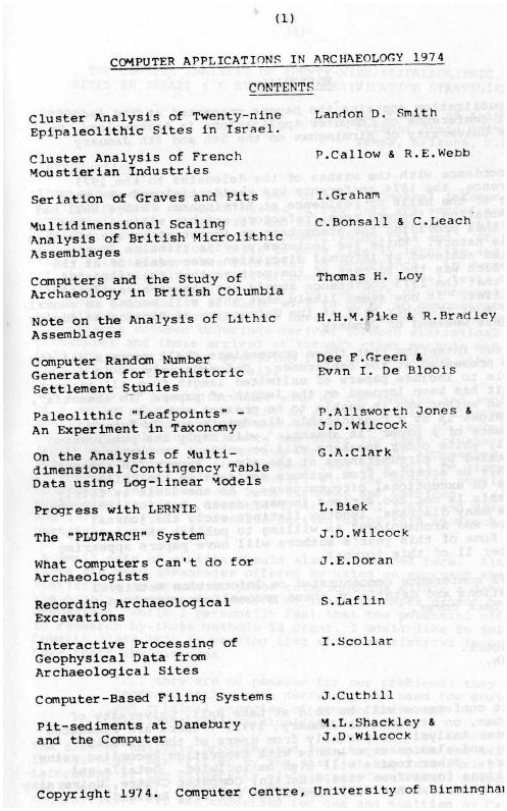

COMPUTER APPLICATIONS IN ARCHAEOLOGY 1974

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Figure 3 Contents of CAA 1973 and 1974

The early development of computational archaeology was reviewed by Irwin Scollar in the 25th anniversary conference of CAA (1999)[10]. Although the impact of the Internet had not truly been felt in 1997 the general context of archaeological computing is clear from Scollar's analysis (figure 4). It is equally apparent that the single major development of this period was the utilisation of geographic information systems for archaeological use (figure 5). Moreover, the adoption of the technology clearly drove a major archaeological agenda with a rapid move from individual early adopters to the emergence of key groupings, such as the Center for Advanced Spatial Technology (CAST) in Arkansas in 1991[11]. It might be suggested that the potential of GIS as a relatively "black box" technology for comparatively computer illiterate archaeologists may have had a number of significant impacts. The increasingly pervasive use of GIS to display, if not always analyse, archaeological data led to a long-running debate on the nature of GIS to wider post-processual theory within archaeology[12]. The view from technologists working within archaeology was, perhaps, less frequently voiced but could be equally vociferous. One "pioneer" suggested to the primary author in 1991 that computers were for "hard sums" and he could see no place for simple software applications in the discipline!

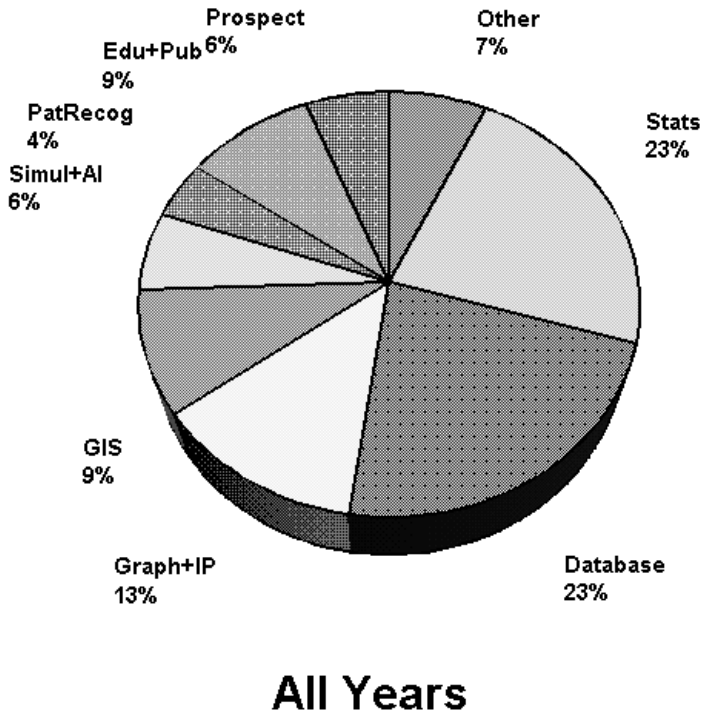

Figure 4 Archaeological computing in 1997 (Scollar 1999, figure 2)

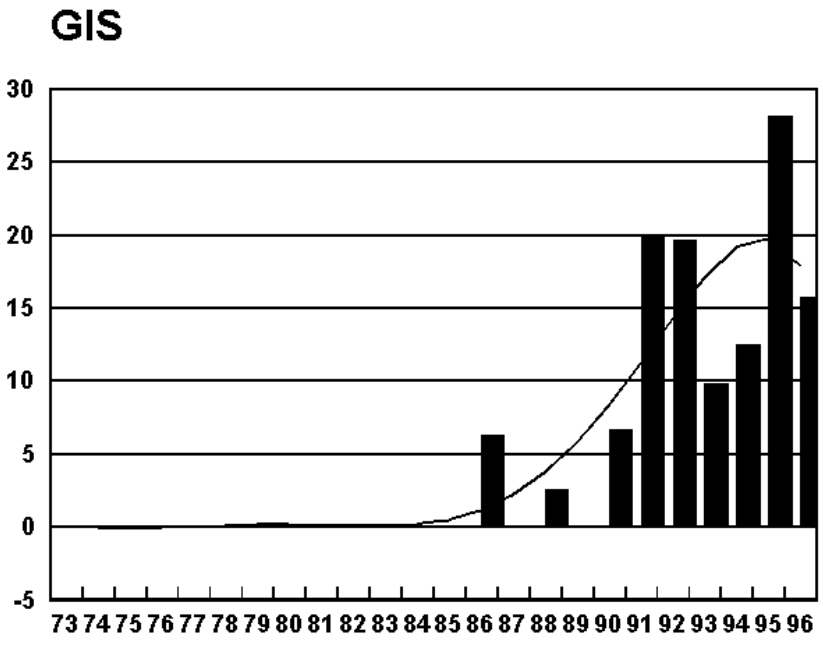

Figure 5 The adoption of GIS within Archaeology (Scollar 1999, figure 2)

However, by the time that Scollar's article was published it was apparent that a number of differing developmental threads had emerged. At Bradford, under the direction of a series of influential heads of department, including Dr Arnold Aspinall and Professors Mark Pollard and Carl Heron, the challenge of cultural archaeology was met with what was called at the time a group of "white coat

scientists and woolly-jumper archaeologists". In contrast, the incipient development of archaeological computing at Birmingham remained largely the preserve of computer science. Although Staffordshire produced a number of eminent archaeologists with computational competence, including Professor Julian Richards at York and Professor Gary Lock at Oxford, the lack of an archaeology department at Staffordshire and the relatively traditional nature of the academic group at Birmingham ensured that any gains were not followed through within the context of an academic department of archaeology. What did happen at Birmingham during the later 90s was a growing awareness within the University field unit (BUFAU and then BA) of the significance of archaeological computing[13]. Unsurprisingly this began with an interest in digital recording of archaeological data but led to the establishment of a formal digital group within the field unit that appreciated the increasing role of digital data within archaeology. Perhaps in contrast to earlier archaeological computing groups, Birmingham appreciated the significance of visualisation as a desirable output in its own right, the value of distributed computing resources, initially through the Grid and then Clouds, and the central role of the Internet as the convergent point of the digital technologies. The title of the grouping that was established reflected this IBM-VISTA (the IBM Visual and Spatial Technology Centre)[14]

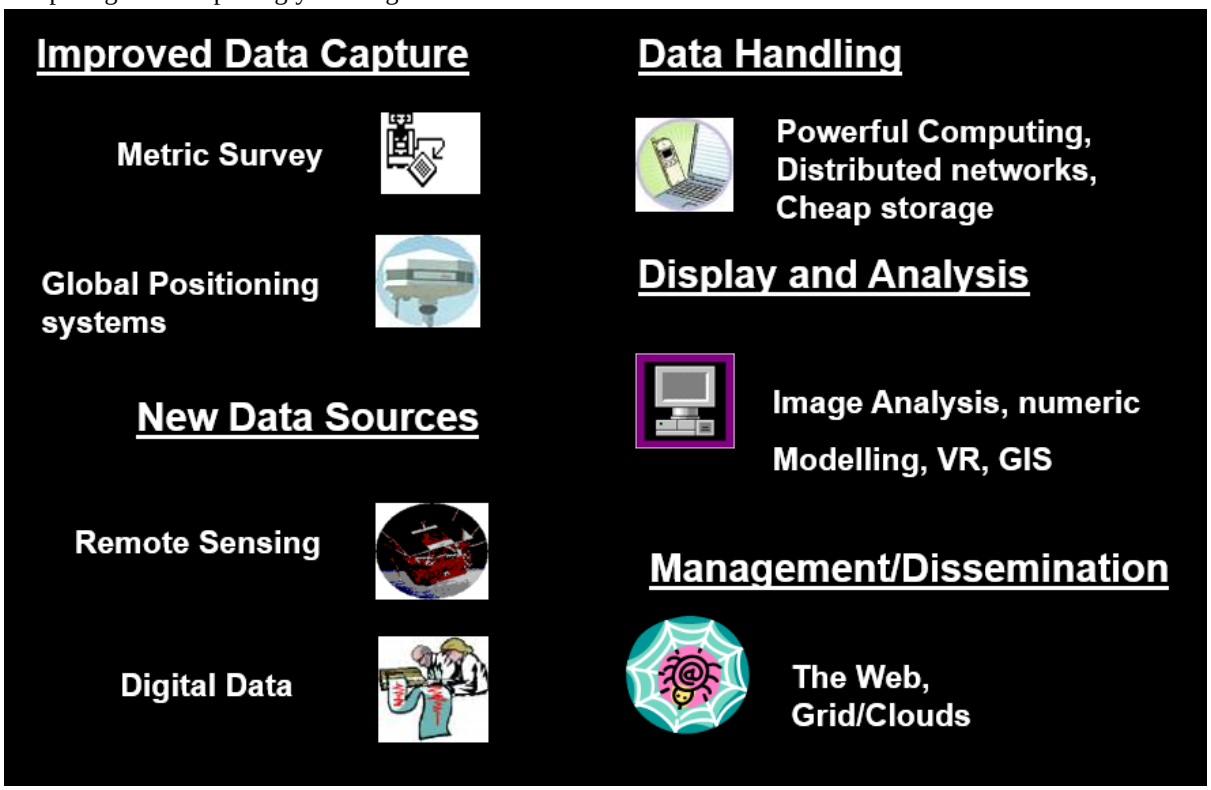

Figure 6 A PowerPoint slide used during IBM VISTA presentations and amended between c. 2002-14.

Not surprisingly, the nature of projects associated with this specific archaeological grouping also developed alongside technology more generally. Large mapping and remote sensing projects, frequently associated with GIS analysis, such as the Wroxeter Hinterland Project[15], had begun to accrete web front ends[16], and the role of gaming engines for display and within more complex simulations throughout the last decade[17].

In part, archaeology, like many other areas of the humanities, was being driven computationally both by public demand and technology itself. The complex nature of modelling human society or action increasingly surpassed the capacity of

traditional analytical methodologies to analyse, whilst the position of some Arts disciplines, perhaps notably archaeology, at the interface with natural science ensured their propensity to generate large amounts of spatial/numeric data and exacerbated such a process. The heterogeneous nature of Arts data generated a requirement for resource discovery and data mining and also a range of complex visualisation technologies for the purpose of representation, interpretation, restoration or aesthetic display. Add to that heady mix the requirement of the Arts for almost constant engagement with the general public, the media and creative sectors. The perpetual need for the implementation of technological but also cultural change within arts disciplines appears to be inevitable.

Archaeology has been no exception to this and, perhaps, this can be seen within the increasing use of replication, conservation and reconstruction within the discipline[18]. Replication has, of course, a long tradition in archaeology and from the model making of General Pitt Rivers – the father of scientific archaeology[19] - whose practices were derived from his experiences within the British Army, through to the more sophisticated, but frequently less aesthetic, outputs of laser scanning and 3D printing technology. Reconstruction has apparently a more troubled history and is frequently contested – although the same may now be said for replication[20]. To a certain extent, of course, such a process simply forces the academic to make explicit the process of interpretation - itself an act of imagination when dealing with objects and structures which may be partial or whose existence can only be inferred through proxy data. Of course, interpretation itself is often a contested arena and although one may sometimes encounter crass models or reconstructions, that is not in itself a reason not to interpret or make explicit the experience of interpretation. After all, we are all, in the long run, wrong!

There may be another issue that drives archaeology's peculiar relationship with complex computational and visual technologies and that is the problem of people. On the face of it, the whole purpose of archaeology is to understand the human past and this presumes a concern with the people who lived there. In fact, people are embarrassingly missing within much archaeological literature and their presence frequently reduced to abstract patterning of artefact distribution, arcane spatial syntax representing movement or frequently embarrassing and/or unrealistic illustrations of fur clad primitives or their historic counterparts[21]. The absence of people becomes more problematic as the environmental and structural sciences provide larger historic scenarios into which people should be able to fit. Good examples of such processes relate to the increasing use of geophysical technologies to provide access to structural data that might represent the detailed behavioural context of groups in specific contexts and here one might consider the reconstruction of landscape liturgies associated with complex ritual monuments or, in extreme cases the reconstruction of the settlement or land use of vast areas of submerged landscapes on many coasts which cannot be explored conventionally[22]. The contemporary use of software agents to explore such extensive or inaccessible environments is now becoming increasingly frequent and the outputs of such software may be characterised by emergent patterning generated by the unpredictable behaviour of millions of individual agents. The potential novelty of such analyses is only matched by the complexity of the implementation of research programmes in respect of the compute requirements and infrastructure that may be required to implement such studies. Add to this the potential for engagement of contemporary populations as sources of behaviour to be mined for insights into past societies and we may begin to appreciate the complexity and potential ethical issues that we might begin to engage with.

In many senses the increasingly sophisticated options related to analysis and display of the past makes us all heritage specialists but archaeology, in particular, may frequently feel the burden of such a position of such a position. Such issues are highlighted when considering the practise and ethics associated with reconstruction or replication in the context of traumatic, contemporary events. The debate concerning the replication of the Palmyran Arch in London referenced earlier, and the associated programme to record heritage, in advance of, or even in the face of contemporary cultural iconoclasm raises the spectre of public responsibility for historic and heritage disciplines in a manner rarely seen by the present generation of academics (Figure 7). What is permissible within the context of armed conflict and contested cultural values becomes deeply problematic.

Figure 7 Destruction of cultural monuments in Syria (left) and Libya (right). Source: English language publication (Dabiq 11).

Where responses are promoted there is a recognition of the need for action not only in respect of documenting damage but also to preserve by record. The latter, in particular, is carried out in anticipation of a post-conflict future in which such data may assist in social reconstruction and the easing of post-conflict tensions. However, the lack of information and adequate response was recently summed up by UNESCO - "Armed conflict and natural disasters pose a dire threat to cultural heritage throughout the Asia-Pacific region. News stories are becoming all too frequent of priceless cultural treasures being damaged or lost forever" – a situation that both people in-country and the heritage community are crying out for help with. "There are currently few measures in place to mitigate the effects of and recover from these dangers – even UNESCO World Heritage sites too often lack these safeguards."[23].

It is certainly widely accepted that new digital recording methods must be one response to this situation, although many current responses relate to artefact reconstruction or large-scale landscape recording[24]. Other proposals seem potentially dangerous to local participants[25]. There is also some sense that the need to create an infrastructure that can operate at a significant level, and can be scaled up to meet future requirements, is unlikely to be met by projects which are restricted simply to crowd sourcing and rely on voluntary participation for development as has recently been proposed [26]). Whilst undeniably part of the solution, such approaches alone would be unlikely to provide the complex infrastructure capable of delivery in the medium term or, importantly, promote sustainability or development in the future.

Curious Travellers, a project run from Bradford uses web and social media data scraping, as well as crowd sourcing, and is intended to go beyond current initiatives[27]. Alongside traditional, searchable archives is a vast untapped source of data presently, and often un-wittingly, stored by the public in the form of holiday pictures, videos, and

descriptions within travel blogs, photo galleries and videos. These represent a modern day treasure trove of digital data that can be acquired, crowd-sourced, or donated through citizen science projects, and used to reconstruct the now lost monuments along with their pre-destruction environments as augmented by remote sensing data.

Crowdsourcing images from volunteers and contributors are not new (e.g., Project Mosul), but these limit content to that derived from aware individuals and groups and, usually, to images. The proposal to crawl the Web for public data, as well as to query Social Media APIs for image data not only of the subject, but also of the surrounding landscapes can provide much additional data that may not be donated under most circumstances. Valuable metadata such as textual descriptions, and geo-location based images embedded within the content (geotagged images, social media geotagging) can be utilised and contextual data inclusive of images, landscapes, geotags, textual description, and even the sentiment of the users may be important for reconstructing cultural artefacts as well as emotive reactions to the artefacts themselves.

This opportunity is provided by advances in open-source scalable software and hardware architecture which, together with pervasive multi-platform applications, makes it possible to crawl and scrape the World Wide Web, as well as provide a platform for the public to provide data for conservation purposes. Unstructured data in various formats on the web, including images and text, can be stored together with an appropriate internal representation that can be obtained from travel blogs for example. Public social media data, such as within Twitter and Instagram, are also searchable for target sites via hashtags and are accessible with APIs together with the images and text associated with them. Location-based information such as geotagged contents can be acquired through these APIs and morphed into a structured format to provide a viable route for delivery. Together with the output of related projects such methodologies may be safer and more ethically desirable than some current proposals for in-country involvement.

A significant characteristic of the Curious Travellers project is the decision, from the onset, to integrate the modular system through a generic, multi-lingual, historic environment record based upon a system originally designed for use in Qatar[28]. There has been a tendency in how academia has reacted to recent crises to simply react to individual acts of destruction or rush to digital preservation as an immediate panacea rather than a sustainable solution. The consequence of such a position is that, amongst much good work, some digital outputs may have lost their cultural context. The potential of Curious Travellers is to create a sustainable toolkit, available freely, that has real heritage value in times of peace as well as during conflict. It may be that the heritage community is compelled to act through necessity in times of conflict but monuments are lost to natural disasters, cultural vandalism and iconoclasm or neglect on a regular basis, and this should not be forgotten. The Curious Travellers project is therefore provided on the expectation of increasing loss and to provide the opportunity for mitigation in a fast moving world in which current crises overwhelm recent catastrophes.

The larger academic context for the Curious Travellers project probably also demonstrates a structural change as archaeological science becomes heritage science. The provision of expertise through the Big Data and Visual Analytics Lab (now NVIDIA Joint-Lab on Mixed Reality) at the University of Nottingham's China campus (Ningbo), and remote sensing specialists at St Andrews, integrated through the HER work of MOSPA[29], is centred on Bradford Visualisation, which increasingly may be viewed as a specific heritage science group leading an academic agenda rather than a scientific grouping serving a local need or fulfilling research council obligations for digital archives.

Whilst recognising the strength that exists within the natural sciences at Bradford, the ubiquity of digital activity provided through the emerging projects increasingly focussed through Bradford Visualisation. Projects including "Digital Diseases" or "ENTRANS" provide good examples of direct, digital encounters with archaeological data at Bradford[30] whilst FossilFinder and Fragmented Heritage utilise crowds to analyse digital imagery as part of a larger project to investigate the fragmentary nature of heritage; to understand how digital approaches might capture, recreate and re-present archaeological data. The Lost Frontiers project is an example of the digital recreation of the

vast, inundated landscapes of the North Sea. Moreover, the application of agent-based modelling as a proxy to investigate these inaccessible regions presents a path towards the analysis of intangible heritage in a context in which intangible might easily be understood as unknowable.

In many senses, Curious Frontiers brings together many of these strands of research and development, integrating crowd-sourced and user-generated WWW and social media data within 3D frameworks and implementing these frameworks at a local level for the wider good. These projects in many ways may be microcosms of future heritage science and are perhaps characterised, in part at least, by the increasing role of the wider public as engaged participants, perhaps even as experts, rather than passive consumers of heritage products, as well as the use of untapped social media to generate critical heritage resources. In doing so the project provides the opportunity, and indeed need, to anticipate heritage through a wider range of methodologies and technologies than has been the case previously.

To return to the beginning: to Harold Wilson's pipe and also to Magritte's witty painting "The Treachery of Images". It is doubtful whether Wilson could have imagined the eventual role of his pipe, either in symbolic or technological terms, but it clearly has both within the University of Bradford. It represents the university's founder as a person and illustrates his dream of development through technology as a digital product. We may consider that it has now entered the brave new world of the 21st century as an exemplar of heritage technology, one which has been recovered from the past, as so much may be recovered through archaeology in a digital age, and has now been projected into the contemporary world as a digital image replete with meaning. René Magritte's playful comment of the role of imagery might seem particularly apposite given such a transformation although one should not consider the SketchFab object as treachery to the original. It might even be an improvement!

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