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## Original Study

## Open Access

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# Challenging Digital Archaeology

**Abstract:** A keynote presentation at the 2012 Computer Applications in Archaeology (CAA) conference in Southampton (UK) proposed the use of grand challenges as a vehicle for identifying and pursuing major advances in Digital Archaeology. At the same time, it was argued that this should be a collaborative venture. This was taken forward at a round table session at the 2014 CAA in Paris, and a number of papers in this volume were presented there. This paper introduces the concept of grand challenges for Digital Archaeology and seeks to define their key characteristics.

**Keywords:** digital archaeology, grand challenge

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## 1 Introduction

There are (at least) two associations sitting behind the idea of ‘challenging’ Digital Archaeology. First, there is the challenge of seeking to advance the subject itself – horizon-scanning to try to identify where the next major advances in Digital Archaeology will be, and their potential impact and significance for the broader discipline and beyond. Secondly, there is the idea of challenge in the sense of something that is difficult, hard to achieve, pushing boundaries, moving into uncharted territories, taking us out of our comfort zones. In this context, therefore, the challenge to Digital Archaeology is to move beyond the norm of incremental change and raise our sights to look for paradigm-shifting developments which separately or together have revolutionary potential.

## 2 The lesson according to Google

This is certainly no mean feat, so how might it be achieved? In fact, this objective underpins the strategy of a very familiar digital corporation: Google. The company whose informal corporate motto is “don’t be evil” has inevitably run into controversy over its power, ubiquity and reach, but part of its philosophy is to develop in unexpected and unanticipated directions:

“We set ourselves goals we know we can’t reach yet, because we know that by stretching to meet them we can get further than we expected ... our constant dissatisfaction with the way things are becomes the driving force behind everything we do.” [1].

In an interview with Larry Page, the Google Chief Executive Officer, Steven Levy describes Page as “living by the gospel of 10x”:

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“The way Page sees it, a 10 percent improvement means that you’re basically doing the same thing as everybody else. You probably won’t fail spectacularly, but you are guaranteed not to succeed wildly. That’s why Page expects his employees to create products and services that are 10 times better than the competition. That means he isn’t satisfied with discovering a couple of hidden efficiencies or tweaking code to achieve modest gains. Thousand-percent improvement requires rethinking problems entirely, exploring the edges of what’s technically possible, and having a lot more fun in the process.” [2].

Google’s X division, set up in 2010, is famously where this approach is pursued. Recent developments have included driverless cars, balloons and solar powered drones to deliver internet services to developing countries, contact lenses with embedded chips to monitor glucose levels in diabetics, three-dimensional mapping, and robotics. This is described as ‘moonshot’ research – looking for ambitious projects which promise big impacts, obviously referencing President Kennedy’s challenge in 1961 to put a man on the moon and returning him safely to earth. How might this be relevant to Digital Archaeology?

### 3 Evaluating Digital Archaeology

While there is little doubt that archaeological use of computers has dramatically transformed the practice of archaeology, there has long been the sense that – in the broader view – archaeological computing has been a follower rather than an innovator. A number of archaeologists in the past have observed that Digital Archaeology provides the technical underpinning of modern archaeological practice, but essentially acts in a supporting role. For example, Lull [3] and Schollar [4] both commented that most of the computer-based tools archaeologists use are borrowed from elsewhere. More recently, Llobera [5] has challenged computer archaeologists, arguing that there is little novel about digital approaches to archaeology, few signs of digital methods creating new approaches to archaeology, and little impact on theoretical aspects of the wider discipline. In many respects, therefore, he concludes that archaeological computing practitioners are little more than technicians. Indeed, the critiques by Schollar and Llobera, separated by almost fifteen years, share remarkably similar conclusions: computer methods rarely lead to new archaeological knowledge beyond making it possible to record and retrieve information faster and in larger quantities than before. These and similar debates have a number of implications for Digital Archaeology. Characterised as essentially a ‘hand-me-down’ discipline [4], they tend to reinforce a view of Digital Archaeology as an under-theorised, subordinate and consequently under-valued field. Coupled with a strong perception of Digital Archaeology as primarily practice-based, it means that Digital Archaeology is rarely seen as more than a service to the broader discipline, and impacts little on disciplines beyond archaeology.

Without denying the value of the use of GIS, large-scale integrated data systems and a wide range of other computer-based tools, the way these have largely been introduced wholesale from other disciplines means that they have tended to be applied to familiar archaeological problems and reinforced the impression of digital archaeologists as little more than technicians providing services to the wider archaeological community. Reassuringly, perhaps, Digital Archaeology is not alone in this regard: much the same is apparent in the Digital Humanities, for instance [6, 7]. Similarly, Information Systems research has been argued to be undervalued in part because researchers in the field had failed to engage with the full range and scale of problems relevant to their work and knowledge [8]. The argument here is that Digital Archaeology researchers have largely done likewise.

While this generalisation is doubtless unfair in some respects and may underestimate the impact of digital techniques to some extent, the tensions evident in these and other discussions surrounding Digital Archaeology can constitute an ‘anxiety discourse’ surrounding the methods, outputs, and intellectual relationships of the field [7]. Far from being a negative, inward-looking process, such a discourse is ultimately aimed at strengthening, reorienting, and rethinking the role, methods, and interactions of Digital Archaeology. It can be easy to overlook the way in which digital tools have become ubiquitous in archaeology, to the extent that they are taken for granted and have become increasingly integral and fundamental to the practice of archaeology, albeit with potentially far-reaching implications which are not always fully appreciated [9, 10]. Fundamentally, however, the question remains whether it is satisfactory that Digital Archaeology is simply conceived as a set of techniques or methodologies borrowed from

elsewhere, or whether it is capable of the intellectual aspiration and technical ambition to develop new tools and approaches that are truly transformative. The level of attendance and interest at a roundtable which sought to ask this question at the Computer Applications in Archaeology conference in Paris (2014) suggested that there is a real desire to pursue this aspiration and ambition.

## 4 The value of grand challenges

One approach to meeting this demand is through the idea of ‘grand challenges’ which are specifically targeted at generating major changes, expanding boundaries, intensifying research activities, and mobilising resources. Grand challenges are very much in vogue: from the US White House [11], to DARPA [12], international aid agencies and many major universities, grand challenges are used as a mechanism for driving forward ambitious research programmes which seek to address major environmental, social, health, technical, and developmental issues confronting the world. The European Union’s Horizon 2020 programme [13], for example, includes ‘societal challenges’ incorporating areas such as health, environment, security, energy, and transport. Grand challenges are a not a new development, however. For example, in 1714 the UK Parliament established a grand challenge to calculate longitude accurately which led to significant developments in clock-making [14]. Nor are grand challenges necessarily successful. While a person walked on the moon within 10 years of Kennedy’s challenge, the human genome was mapped in 2006 after 20 years’ work across 20 research centres, and the Higgs boson – theorised in 1964 and actively sought from the 1990s – was shown to exist in 2013, cancer has yet to be cured, fusion energy generation is not yet viable, climate change continues unabated. Furthermore, in some instances – for example, the search for synthetic pesticides which led to the development of DDT – there may be unintended consequences [8]. Nevertheless, the benefit is frequently in making the attempt, or, to paraphrase Kennedy’s ‘moonshot’ speech to the audience in Rice Stadium on September 12th 1962, we do so not because such challenges are easy but because they are hard, and because in attempting them they will serve to organise and reinvigorate our energies and skills.

## 5 What constitutes a grand challenge?

The characterisation of a grand challenge often seems to be taken for granted – as Kalil [15] observed, there is no universally accepted definition although it is something that is self-evidently difficult and challenging to achieve. However, a grand challenge has to be ‘hard enough’ both to warrant the name and the investment of time, energy and resources into achieving it and yet not ‘too hard’ such that it is situated in the realms of science fiction or fantasy. This means that a clear definition is vital in distinguishing between something that is simply hard, and something that presents a genuine challenge worthy of the name.

While there may indeed be no universal definition, Kalil [15] outlined a number of general features of grand challenges which have been applied to the scientific study of the human microbiome, the search for a cure for cancer, etc.; others have highlighted features of grand challenges associated with computing more specifically (for example, [16, 17]) as well as those more closely linked to digital heritage and archaeology (for example, [18, 19]). Some of these are discussed in more detail elsewhere [7], but Table 1 demonstrates that despite different emphases and different objectives, there is a deal of commonality between the different definitions. Leaving aside some of the more obvious characteristics, it is clear that a grand challenge has to engage the community, both in the narrow sense of the immediate field of Digital Archaeology, and also more broadly – the wider archaeological discipline, not simply in academia but in the professional and commercial spheres as well as the avocational community. This underlines the need for the challenge to be comprehensible, facilitating buy-in from non-experts and other disciplines alike who recognise the challenge and value its potential outcomes. Kalil [15] talks of the need for a “‘Goldilocks’ level of specificity and focus” – the idea that a challenge needs to have just the ‘right kind’ of scale and detail. Too much detail, too narrowly defined, and the challenge is diminished by relying on the achievement of one highly specific goal; too large a scale, too general, and the challenge becomes insurmountable and infeasible. For

example, ‘to improve archaeological practice’ is too vague to make any sense, but ‘to enhance access to archaeological data online’ is also too imprecise, as it provides no indication of how we might approach it, or, indeed, how we might recognise that the objective has been achieved.

The most recent and most extensive foray into grand challenges for archaeology arose from the National Science Foundation (NSF) funded programme on *Planning Archaeological Infrastructure for Integrative Science* [20] which used the identification of grand challenges in order to develop proposals for major future NSF investment in cyberinfrastructures for archaeology. The result was 25 challenges across five themes, focussed on cultural processes and human/natural systems, and the steering group concluded that these challenges were underpinned by a digital challenge – the need for online access to documented primary research data and to unpublished reports ([20] and Kintigh, this volume). Nevertheless, what essentially remains undefined are criteria which define a ‘grand challenge’ in the Digital Archaeology realm.

**Table 1:** Key attributes shared across several definitions of Grand Challenges.

Kalil [15]	UKCRC [16]	EPOCH [18]	AHRC e-Science [19]	McGettrick et al [17]
Have a major impact on the domain	Lead to radical paradigm shift			Lead to substantial improvement
Ambitious but achievable	Ambition to create something truly novel and innovative			
Compelling and intrinsically motivating – fire imagination	Enthusiastic support from the broader community and be comprehensible outside the discipline	Interdisciplinarity – collaboration with domain experts and non-professional user-groups	Involve and be embedded within the whole community	Arouse curiosity and generate enthusiasm within the community; be comprehensible and capture the imagination
A ‘Goldilocks’ level of specificity and focus	Be capable of decomposition into intermediate goals which are beneficial even if the project as a whole ultimately fails – and know the extent to which and when the challenge has(not) been met		Be international, scaleable, sustainable, implementable; failure is not necessarily bad as long as lessons are learned	Be international in scope and so have wide and significant relevance
Drive and harness innovation and advances	Go beyond what is initially possible and develop understanding, techniques and tools that are currently unknown	Potential for new or enhanced technological capability, not customising what is already available; technology transfer from other disciplines is low priority	Be considered fundamental research, pushing the boundaries of the use of ICT in research	Have the capacity to bring about changes in attitudes, expectations, and even change at the social level
		Relevance for cultural heritage organisations and their constituencies	Focus on the needs of archaeology and assessed on the basis of archaeological values, rather than technology-driven, or judged by the standards of the donor discipline	

## 6 Parameters of grand challenges

Determining whether or not a significant research problem is worthy of being considered to be a grand challenge in terms of Digital Archaeology is unlikely to be straightforward or clear-cut, but a number of interrelated characteristics can be derived (drawing on [16, 18, 19] in particular) as a means of evaluating potential candidates.

1. It should be **fundamental**, dealing with the basic essentials of Digital Archaeology, and of archaeology itself. Consequently, it is likely to address archaeological theory as well as practice. It should be defined by archaeologists rather than other specialists (a criticism that can be directed at some earlier challenges relating to digital cultural heritage, for instance [7]) although, despite being assessed on the basis of archaeological value, the fundamental nature of the challenge should mean that aspects of it have value for other disciplines as well.
2. The **scope** of the research question should provide sufficient range and capacity that it can be truly innovative, rather than simply adopting concepts and techniques from other fields. Taking a technique or technology from one context and applying it in another is not in itself sufficient to constitute a challenge. This is because:
3. It should be **revolutionary**. There is a strong element of ‘blue-sky’ thinking: it is not something that will naturally evolve in time through practice. There should be the potential for paradigm change, with the creation of new technological capabilities and ways of knowing. It will require new ways of thinking, new tools, and new techniques – indeed, the creation of these is very much the nature of the challenge at hand. This would underline the suggestion that the level of technology transfer from other disciplines in achieving the objective will be relatively limited.
4. It should be **inspiring**. A challenge not only requires the enthusiastic support of the Digital Archaeology community but should also engage the whole sector from professional to non-professional to interested public; it is not just an academic exercise. It should also be capable of generating enthusiasm in other disciplines if it is to successfully create impact beyond Digital Archaeology. Consequently it should also be **understandable**: capable of being communicated in terms that capture the imagination of the public as well as specialists in other disciplines, ensuring that it is not excessively inward-looking.
5. It should be **measurable**, with a defined endpoint and intermediate goals which can be used to gauge progress and achievement as well as enabling risks to be identified and managed. Challengingly, given the contemporary research environment, ultimate failure should not imply a lack of success if the sub-goals have been won and benefits gained in the process.
6. It should be **co-operative**, involving more than just an individual researcher or even a single team, but drawing on experts collaborating across national and, potentially, disciplinary boundaries. Co-operation does not imply a single approach or single solution, however.

What these characteristics underline is that a grand challenge is not the same as a ‘typical’ research project. For instance, transferring a particular tool, technology or conceptual framework from a donor discipline and applying it in an archaeological context may well underpin a successful research project, but it does not constitute a grand challenge unless a number of the criteria above apply [7]. This is to follow Hoare [16] in recommending that these criteria do not comprise a simple tick-list; instead they represent a series of desirable guidelines to act as the basis for evaluating any potential challenge.

## 7 The Grand Challenge for Digital Archaeology

The argument, therefore, is that as digital archaeologists we should be more ambitious, and develop innovative digital tools and methodologies which have the potential not just to transform archaeology but also multiple academic fields and communities beyond. The pursuit of ‘grand challenges’ in this regard sets the bar high. They require us to be innovative, international and interdisciplinary, and, of course, they should be difficult to achieve. They should not be ‘typical’ research projects or ‘more of the same’; crucially

a grand challenge is not incremental but jumps ahead of the curve, leading to a radical paradigm shift. This means that grand challenges entail not just looking into the future, but seek to implement that future.

A challenge needs to be compelling so that people recognise its value, it captures the imagination, it motivates and inspires. Nor is it solely a technical challenge – it is not so much “what can we do?” as “what should we do?”, emphasising that it is not simply a matter of the technology driving these challenges – what is important are our ambitions for the subject, and only then the ways in which digital technology might be used to catalyse, support, develop, and enhance those innovations. Rather than fetishising technology [10], this approach also avoids the perception of Digital Archaeology as essentially little more than a technical support infrastructure (e.g. [5]) and instead seeks to ensure that Digital Archaeology is a means of rethinking archaeology, rather than simply consisting of a series of methodologies and techniques.

Nor should achievement be necessarily measured in terms of success – as important as the end result can be the journey that is undertaken. Not all ventures meet with success, but the lessons learned and the knowledge gained can be valuable in future developments. For instance, work on artificial intelligence techniques in archaeology during the 1980s never transformed the subject in any significant respect, but many of those same techniques are re-emerging in new areas, helping to categorise and mine large and complex datasets rather than seeking to create something akin to digital avatars. So failure can be as valuable as success since the lessons learned can be reapplied to new challenges in the future. In the dog-eat-dog world of competitive grant capture, failure is not something to be countenanced but recognition of its possibility and its value is an important aspect of pursuing grand challenges.

So the grand challenge presented here is for digital archaeologists to simply engage in the process of creating and pursuing grand challenges in the first place. However, the process of identifying grand challenges is something of a challenge in itself, and so part of this challenge is that it should be done collaboratively. Identifying grand challenges is not something that should be done by an ‘expert panel’, but they should be discussed and debated widely before coming to a collective view. That said, although it is important that there is agreement on the ultimate objectives in recognition of the effort and resources which will inevitably be expended, there is no need for agreement on how they are to be achieved. However, if we are to have that transformative impact on the wider archaeological field by design rather than through incremental drift, a collective vision of the directions in which we are heading is important, and contributions to this volume are but a first step in this regard.

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