MOBILE DECISION MAKING AND KNOWLEDGE MANAGEMENT
Supporting Geoarchaeologists in the Field

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Abstract: There is a professional responsibility placed upon archaeologists to record all possible information about a given excavated site of which soil analysis is one important but frequently marginalised aspect. This paper introduces SASSA (Soil Analysis Support System for Archaeologists), whose primary goal is to promote the wider use of soil analysis techniques through a selection of 'web based' software tools. A description is given of the field tool developed which supports both the recording of soil related archaeological data in a comprehensive manner and provide a means of inferring information about the site under investigation. Insight is gained through a user evaluating numerous decision trees relating to pertinent archaeological questions. Whilst the field tool is capable of working in isolation, it offers a superior experience when operated in unison with a Wiki. A brief discussion of the use of the Wiki application within the SASSA project is presented.

1 INTRODUCTION

Applying geoarchaeology techniques to in-situ monitoring of archaeological deposits can be an arduous task for a non-specialist. They have to identify questions relevant to the site and determine suitable analytical techniques and sampling methods to employ, all of which require complex decisions to be made. Although there are many sources of material citing good practice when analysing site deposits, the nature of an archaeological dig does not easily facilitate access to such information.

This paper introduces SASSA: a Soil Analysis Support System for Archaeologists. SASSA is a mobile knowledge-based tool that provides a means by which pertinent information used to assist in analysis is easily accessible yet provided in a comprehensive manner. In addition, SASSA incorporates decision support technologies to aid the archaeologist in both their analysis of a site and recording of important site data.

In Section 2 we begin by discussing the field of geoarchaeology, highlighting some of the issues that contribute to the complexity of the area. Section 3 reviews the current state of mobile decision support research and outlines the relevance of SASSA to this domain. Section 4 focuses on the SASSA field tool with the underlying technology described in Section 4.1 and use of the tool discussed in Section 4.2. Section 4.2 also illustrates how the tool might be used by means of an example scenario. Conclusions and future work are provided in Section 5.

2 GEOARCHAEOLOGY

Geoarchaeology is a broad discipline with much to offer the archaeologist. Geoarchaeological research has addressed a diverse number of issues; it has been applied not only to archaeological sites and landscapes, but also to experimental and ethnographic research, and *in-situ* monitoring of archaeological deposits.

The archaeological questions addressed by soil analysis fall broadly into two categories; site-specific and landscape level. At the site level there are issues over formation processes involving the anthropogenic, depositional and human history of the site. Such studies address the nature, source and processes leading to the accumulation of deposits through, for example, the use of multi-element analysis to address space use and the identify functional areas (Entwistle et al., 2000; Knudson et al., 2004; Wells, 2004) and the effects of bioturbation (Balek, 2002; Grave and Kealhofer, 1999) phosphatisation (McCobb et al, 2003), and waterlogging (Caple, 1998) on the integrity of the stratigraphic record. At the landscape level questions concern human-environment interactions, for example, the impact of human activity on erosion in the wider landscape (Wilkinson, 2005), resource management in archaeological landscapes (Simpson et al, 1998) and the effect of large scale natural disasters on settlement location (Goff et al, 2003).

The complexity of the area means it can be difficult for a non-specialist to identify the questions relevant to a particular site and match this to the relevant analytical techniques and sampling methods or to critically evaluate the results. There is a good geoarchaeological knowledge base already available; it is the presentation of this material in a manner that is easily accessible and comprehensible to an interested non-specialist that is lacking. An example of this is the use of multi-element techniques to address questions of space use across sites, or to identify sites within the landscape. The question being asked influences the sampling regime, and case studies of these two approaches might include the identification of site extent at Shapwick (Aston et al., 1998), or the identification of activity areas in a classical site in Honduras (Wells, 2004). English Heritage guidelines (Avala et al., 2004) provide questions associated with different types of deposit linked to methods of investigation and field diagnostic tools, such as finger texturing flow charts, but access to specialist literature and the time needed to absorb the specialised information are still a problem for many archaeologists.

The development of the Soil Analysis Support System for Archaeologists (SASSA) is aimed at addressing the issues outlined above.

3 MOBILE KNOWLEDGE AND DECISION SUPPORT

Knowledge management systems embrace heterogeneous approaches for representing and processing human knowledge to enhance decision-making capability of human decision-makers (San Pedro et al, 2003). With the event of mobile and networked environments, there is a need to further the approaches used. Mobile decision support and knowledge systems have to handle the difficulties and complexities brought about by context changes in a mobile computing environment.

Mobile computing is a new technological paradigm in which users access services via a range of devices through a shared infrastructure, regardless of their physical location or movement behaviour (Zaslavsky et al, 1998). Complexities and uncertainties which derive from ensuring portability of applications for a wide range of mobile devices include frequent change in mode of operation, high variability in performance and reliability, issues surrounding visual display capabilities, finite sources of energy, and facilitating recognition by the system of the user, device and environment in which the mobile computing takes place.

Related work in the area of mobile computer support focuses on development of knowledge-based services on hand-held computers (San Pedro et al, 2004; Cowie and Burstein, 2007). For example, work on mobile clinical support systems, addresses decision support such as knowledge delivery on demand, medication consultant, therapy reminder (Spreckelsen et al, 2000), preliminary clinical assessment for classifying treatment categories(San Pedro et al, 2003; Michalowski et al 2003), and providing alerts of potential drugs interactions and active linking to relevant medical conditions (Chan, 2000). Most of these mobile support systems use intelligent technologies and soft computing methodologies (e.g., case-based reasoning, multi-attribute utility theory) as background frameworks for intelligent decision support.

This research builds on our existing work in the area of mobile knowledge management, to provide a central repository of archaeological information, which is not restricted to location or platform. The research addresses the changing way in which information is required and decisions are made, the impact this has on the type of systems developed, and the emergent technologies that facilitate such support. Our existing work in the area of developing cross-platform systems designed for mobile / (office) (Hodgkin et al, 2004; Cowie et al, 2006) has

highlighted the suitability of such approaches to a wide array of application areas. The SASSA field tool extends this work both in the application area it addresses and the technologies it uses.

4 THE FIELD TOOL

4.1 Technological Design

The field tool is tailored primarily towards two categories of hardware device, static and mobile, which in turn facilitate the use of the tool within certain environments. The mobile category includes devices such as a PDA (Personal Digital Assistant) or 'Smart phone' whilst the static category comprises of the more traditional desktop or laptop computer. However, the two distinct functional aspects of the field tool, recording the archaeological data and evaluation of the data through the use of decision trees, are both performed through the same user interface and processing engine. The ubiquitous HTML (Hyper Text Mark-up Language) browser was identified as the most flexible interface for this application, permitting user access via the hardware devices listed above. The web interface technology used is Sun Microsystem's Java servlet technology which is now common place within e-commerce applications. Servlet technology was chosen due to the availability of suitable API's (Application Program Interface), ease of design / implementation of user session handling and its scalability under load conditions. The Java servlet based system, used in conjunction with the Apache Tomcat servlet engine which assumes all conventional server responsibilities, ensures that the tool utilises 'open source' code and is thus freely available to all users.

Use of XML for data encoding
Through discussions with the domain specialists it was determined that data storage requirements for the project were not excessive and therefore both user specified data and 'knowledge data' could be stored within a proprietary XML (eXtensible Mark-up Language) format data file. 'Knowledge data' is defined within this tool as both descriptive content and information associated with implementing the tool. The XML format file is processed internally using DOM (Document Object Model) methodology to permit ease of manipulation and processing of data. SASSA then produces output XML which is rendered into XHTML through the use of XSLT (eXtensible Style-sheet Language Translations) technology. The output XML provides the structure

for the output content which is formatted for the particular graphical user interface (GUI) of a given user. The XSLT translation provides the flexibility to tailor the style of presentation to the browser being used. For example, the same output XML will be used to generate different XHTML content depending upon whether the user is accessing the SASSA system via a PDA or desktop PC. It can also be used to alter content to suit particular browsers or even generate PDF equivalents of XHTML forms.
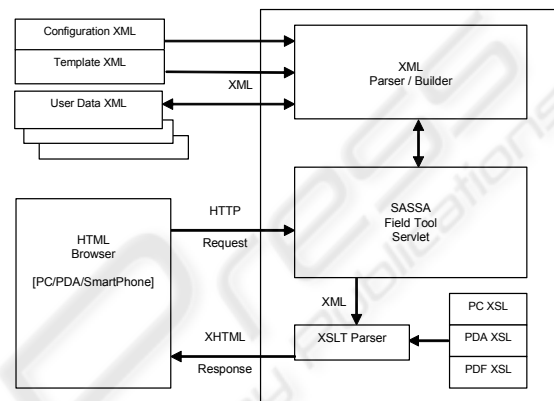

Figure 1: SASSA System Architecture.

A system diagram of SASSA is shown in Figure 1 illustrating the principle software components and their inter-relationships. The normal process is for a user to log in to the SASSA system at which point their XML data is loaded into SASSA. A section of this XML data is then requested, for example a 'Site Details Form'. The XML data encoding the site details is processed into an intermediary XML output format conveying more display related information. This is then processed via an XSLT to produce XHTML, and returned to the requesting browser/device.

The SASSA field tool uses decision trees to aid the geoarchaeologist in inferring information about the site they are investigating. Insight is gained through a user choosing from a compilation of pertinent archaeological questions, each selected for revealing the most information about the focus site and ease / accuracy of answering. A decision tree is formulated for each question comprising of a series of sub-questions. It was felt the use of decision trees (rather than other decision support techniques such as case-based reasoning) was appropriate given that feedback as to how an answer is attained is easy to provide using this technique. In addition, the infrastructure of decision trees seemed to be the closest match to the current way in which decisions

about soil structures are made, thus facilitating an easier transition from paper-based methods to the SASSA tool than had a different approach been adopted. A decision tree is constructed within a proprietary XML data structure and evaluation follows a standard 'weighted sum' methodology to produce a specific 'score' for the question for a set of specified answers to the sub-questions. The score is presented to the user in a tabulated format that contains not only the specific information on how to interpret their score but that of other possible scores in the answer range. This presentation format allows the user to determine whether their results are 'border line' between score categories and thus draw their own conclusions on the presented data. The proprietary XML structure contains not only presentation data (e.g. question text) and processing data (e.g. weighting value for an answer) but allows the implicit hierarchy of decision trees to be captured through a combination of recursive data structures and internal processing path links. A similar hierarchical design structure is used for storage of the site information archive and therefore a common 'XML processor' has been used to interpret both data structures.

4.2 Use of the SASSA Field Tool

When recording the archaeological record of a new excavation two key aspects from a soil science perspective have been identified; consistently recording relevant data across multiple samples and providing answers to a range of pertinent questions which reveal more general information about a particular site. Both of these functions have been
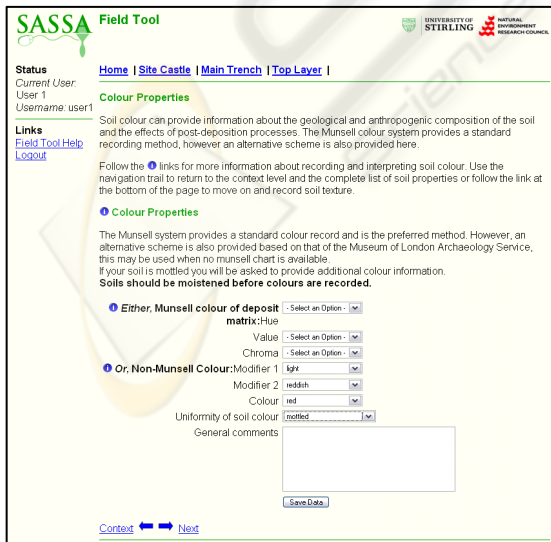
Figure 2 : SASSA Site Details.

incorporated into the SASSA field tool. It is envisaged that SASSA will be used both 'on site' for immediate help with excavation decisions or in an office environment when analysing retrieved data. To facilitate this, SASSA is operable on a variety of hardware platforms, each tailored to permit ease of use within different situations. For example, operating the field tool on a PDA (personal digital assistant) or 'Smart Phone' will allow recording of data within the excavation trench of interest. Operation on a laptop/desktop PC within a site office can facilitate group discussion on recorded results at the end of a day's recording activities.

4.2.1 Example Use of SASSA

Recording site information

Prior to a team of archaeologists arriving at an excavation site, a significant amount of preparation work and information gathering has been performed. Some of this data is pertinent to the soil record of the site and is important to document. Site information
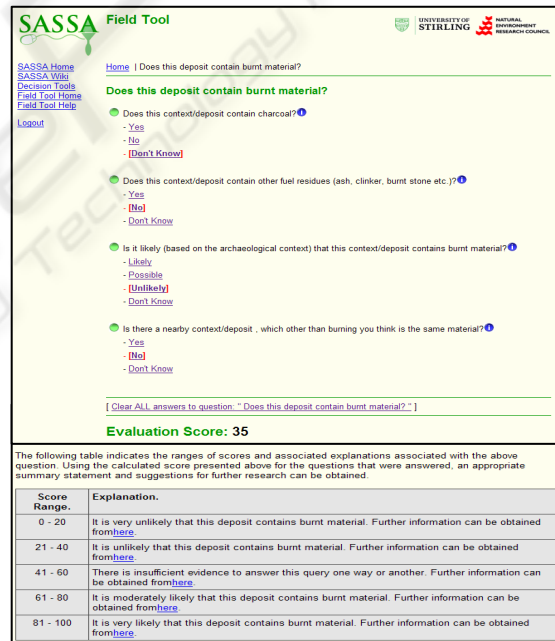
Figure 3: Field Tool Interface.

is recorded in a hierarchical manner, where data can relate to the site itself, specific sections or trenches within a site, and contexts or layers within each section. In accordance with this hierarchy, the SASSA tool provides the facility to enter data about all aspects of a site as appropriate. In the screenshot shown in Figure 2, we can see the user is providing colour information for the Site Castle / Main Trench

/ Top Layer. The user is supported in this data collection activity with a clear, 'form style' format of data entry and links to textual definitions of unusual terms and other information sources (such as diagrams, photographs and case studies).

Use of decision trees for soil context discovery

The SASSA field tool uses decision trees as a means of identifying the likelihood of certain soil properties being present at a given site. Currently, the tool focuses on what we regard as four of the most prominent properties investigated at a site: the presence of burnt material, whether the burnt material (if present) occurred in-situ, the presence of buried soil, and whether the deposit is natural. By walking the user round the decision tree associated with each of these properties, the tool collates knowledge of the site and provides inferences concerning the soil context. Figure 3 shows an example of the questions the user is asked in relation to the issue of burnt material. The questions asked, and how the information provided by the user, is utilised in providing new information to the user dictated by the decision tree associated with the issue being explored. In the example shown, the answers supplied by the user provide an evaluation score of 35. As is depicted at the bottom of Figure 3, score ranges are provided along with how such scores should be interpreted.

In addition to providing inferences about the site, suggestions for further routes of investigation are given. Such investigations include suggestions for further tests that could be conducted and links to further material provided by the SASSA tool that could provide relevant case study or background information.

5 CURRENT AND FUTURE WORK

SASSA Extensions
The current focus of our work involves development of the main SASSA website as a Wiki, from which the field tool can be accessed. The 'Wiki' class of software tool, typified by the world's largest on-line encyclopaedia 'Wikipedia' (Aronsson, 2002) allows browser displayed content to be uploaded and modified by registered users rather than just the site developer. This ensures that content can remain accurate and applicable as well as evolve with the subject over a period of time. 'MediaWiki', has been adopted for the SASSA system since it is the

technology on which 'Wikipedia' is based and users are therefore more likely to be familiar with it.

SASSA Evaluation
Acceptance of the SASSA tools by the intended user community is critical to the success of this project. At the current stage of development, most effort has been assigned to developing prototype versions of the field tool. Evaluation of these development models thus far has taken place through informal discussion with a small selection of interested persons. It is the intent however, to evaluate the prototype tools more thoroughly at a series of formal sessions across the UK at regular intervals in the remaining time of the project.

Application to other domains
The infrastructure of SASSA has been developed such that it is independent of the application, ensuring portability of the system. We hope to investigate other areas where the tool might be applied once all components of the software are complete.

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