The use of traditional and computer-based Visualization in Archaeology: a user survey

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Abstract
Visualization methods are commonly used during the successive stages of the archaeological process. However, it is difficult to determine which methods are more intensively used in each stage and, also, which stage of the archaeological process is more demanding regarding visualization needs.
Within a broader questionnaire regarding the use of computer tools, archaeologists were inquired about their use of traditional and computer-based visualization methods during the different stages of the archaeological process. The main survey results concerning visualization methods are presented and briefly analyzed.

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1. Introduction

According to [Mar00], an archaeological excavation comprises two approaches: (1) the exposure of vertical sequences of deposits that reflect the long-term occupation of a site and (2) the recovery of horizontal plans of individual features or particular periods of occupation. Therefore, and despite the growing importance of non-destructive exploration methods, the archaeological excavation remains a fundamental process for collecting data from archaeological sites. Although it is an irretrievable destructive method, its purpose is not only to unveil successive sediment layers, findings and structures, but to record data and produce graphical and written documentation of every finding.

Visualization methods support the communication of implicit knowledge and encourage new thinking [LE07]. The importance of modelling and visualization methods in the dissemination of visual representations of archaeological interpretations is widely recognized. However, for other stages of the archaeological process the relative importance of such methods is still an open issue. Moreover, the use of modelling and visualization methods is not restricted to the different stages of the archaeological process. It is also crucial

to assess their use in the representation of archaeological entities such as artefacts and finds, stratigraphic units and architectural structures.

An efficient methodology to evaluate how modelling and visualization methods are being used by archaeologists during the various stages of the archaeological process, as well as to represent different archaeological entities, is to conduct a user survey. Within a much broader survey, designed to evaluate the use of various computer tools in Archaeology, a set of questions was developed to evaluate the use of modelling and visualization methods during the stages of the archaeological process and for the representation of archaeological entities.

The next section will briefly describe how the user survey was designed and validated and to whom it was sent. The third section will present the main results and a first analysis of the survey data, regarding traditional visualization methods, and computer-based realistic (i.e., using accurate geometrical and physical features) and non-realistic (i.e., partially based on data interpretation) visualization methods and techniques used in Archaeology. The last section will summarize the main results and present some conclusions.

2. User Survey

The methodology to carry out a user survey is clearly divided into three distinct stages: (1) the design, validation and sending of the questionnaire; (2) the answering process; (3) the validation, analysis and interpretation of the received responses with the purpose of drawing some conclusions.

2.1. Design of the Questionnaire

In order to ensure clearness and conciseness, the global questionnaire regarding the use of computer tools was structured in four distinct sections: (1) *Personal Data*, (2) *Computer assisted tools in Archaeology*, (3) *Computer-based modelling tools in Archaeology* and (4) *Computer-based visualization tools in Archaeology*.

Archaeology often deals with a certain degree of uncertainty [SMI99] [ZCG05] [SWMW07], therefore it is important to understand if realistic and non-realistic visualization methods are used and what kind of visualization techniques archaeologists prefer. The four sets of questions of the last section of the questionnaire focus on the purpose of computer-based visualization tools and the context in which they are mostly used.

The first set of questions is related with the use of the traditional visualization tools (*Scale Model*, *Maps/Cartography*, *Archaeological Drawings* and *Archaeological Illustration*) in Archaeology. The aims are to understand (1) if archaeologists consider traditional visualization tools important, (2) if they effectively use them and (3) which of the traditional visualization tools do archaeologists effectively use. The next group of questions regards realistic visualization methods. In this case the aims are to understand (1) if archaeologists are familiar with them, (2) in which phase of the archaeological process are they mostly used and (3) what archaeological entities are mostly represented using these methods. The third set of questions has the same objectives as the previous one, but for non-realistic visualization methods. The last group of questions is concerned with which visualization techniques are used for visualizing/representing archaeological data.

To the best of the authors' knowledge, no similar work has been carried out yet regarding the use of visualization and modelling tools during the archaeological process and for the representation of archaeological entities. Therefore, the design of the questionnaire was a careful and progressive task, since the questions and the types of answers had to be the most appropriate and clear.

Since the survey was intended to assess the use visualization and modelling tools, most of the answers are chosen from a five point ordered frequency scale. The values of the scale comprise *never*, *rarely*, *sometimes*, *often* and *always*. Thus, the respondents are asked to rate the frequency in which they use certain methods or techniques, both during the different phases of the archaeological process or to visually represent different archaeological entities. Some other answers are selected from a five point ordered quantity-rate scale to assess the importance of some visualization or modelling methods/techniques. This quantity scale comprises the values *not at all*, *poor*, *some*, *plenty* and *extremely*.

2.2. Validation of the Questionnaire

The validation of the questionnaire was carried out by four archaeologists from the Archaeological Unit of the University of Minho. The chosen archaeologists have a wide experience in the coordination of archaeological excavations and two of them are faculty members of the History Department of the University of Minho.

The assignment of these archaeologists was to read the questionnaire carefully and check whether the questions were worded in an appropriate manner and were intelligible. They also gave valuable suggestions that were considered for redesigning some parts of the questionnaire.

2.3. Implementation & Distribution of the Questionnaire

The survey was implemented using *Google Docs*, which has a free, web-based *form* service that enables the creation of a questionnaire in a simple way [Kar11].

According to [Rob12], a statistical significant sample is supposed to have more than 50 responses, however [BIS11] refers that 30 to 60 answers should provide meaningful results. To get the largest number of responses possible, the URL of the web-based questionnaire was distributed, by e-mail, to a set of archaeologist known to the authors. Also, for the participants to be as representative as possible, the link was sent to two different archaeologists groups (*Quaternary Prehistory Mação Google Group* and *Linkedin Group CAA: Computer Applications and Quantitative Methods in Archaeology*).

2.4. Data Collection & Validation

Over three months, 39 responses were received from archaeologists working in Portugal, Spain, UK, Germany, Italy and Greece. However, most of the responses came from Portuguese archaeologists. All responses were immediately stored in *Google Docs*, for later processing. Except for two responses, all were accepted for this survey.

The age of the respondents varies between 23 and 51 years old and the median age of the sample is 31. Regarding he professional experience, the respondents have between 1 and 30 years of experience and the median of professional experience is 8 years.

The number of responses is relatively balanced from

archaeologists that work in Universities (12), Public/Governmental Institutions (13) and Private Companies (9). Also, the respondents had more experience in Iron Age, Roman Period and Middle Age and less experience in Palaeolithic, Mesolithic and Neolithic Period.

3. Results

To try to understand how visualization tools and methods are used in Archaeology, the responses to the four sets of questions of the questionnaire's last section were analyzed.

When evaluating whether or not archaeologists use particular visualization tools or methods, the responses are grouped as:

- N/R – if there is a no answer;
- Yes – if the answer ranges between *rarely* and *always*;
- No – if the answer is *never*.

3.1. Traditional Visualization

The traditional visualization techniques considered in the questionnaire are: *Scale Model*, *Maps/Cartography*, *Archaeological Drawings* and *Archaeological Illustration*. Table 1 summarizes the answers by the survey's 37 respondents.

	Yes	No	N/R
Scale model	25	4	8
Maps/Cartography	33	1	3
Archaeological Drawings	32	0	5
Archaeological Illustration	34	0	3
Other Traditional Visualization Technique	2	10	25

Table 1: *Use of Traditional Visualization*

Table 1 shows that almost all of the respondents use archaeological illustrations, maps and drawings, whereas a smaller number uses scale models.

The validated answers also show that 26 of the respondents consider very or extremely important the use of traditional visualization techniques, and that those are actively used by the responding archaeologists. There is even a greater preference for traditional visualization tools among the younger archaeologists responding to the survey than among the older ones.

3.2. Computer-based Visualization Tools

For 31 of the 37 responding archaeologists it is very or extremely important to use computer-based visualization tools: 20 among them think it is extremely important to do so. Regarding the effective use of computer-based visualization tools, 31 respondents use them regularly and they are more often used by older archaeologists.

The use of realistic and non-realistic visualization methods is not homogeneous. Younger archaeologists tend to use realistic visualization methods mostly during the archaeological process, while older ones use it more to represent archaeological entities/objects. The contrary happens with non-realistic visualization methods.

3.2.1. Realistic Visualization

Realistic visualization methods entail data representations based on accurate geometry or physical properties. Identifying for which stages of the archaeological process realistic visualization methods are mostly used, as well as for which kind of archaeological entities, will enable improving existing methods and designing new computer-based visualization tools.

Table 2 illustrates the use of realistic visualization methods throughout the different stages of the archaeological process and considering different archaeological entities.

	Yes	No	N/R
Post-Processing of Archaeological Record	23	6	8
Analysis & Interpretation	23	5	9
Research	20	8	9
Dissemination	22	5	10
Artefacts & Finds	23	4	10
Stratigraphic Units	20	7	10
Structures	24	4	9

Table 2: *Use of Realistic Methods*

Although there is a significative number of non-responses, realistic visualization methods are used by a majority of the surveyed archeologits troughout the differente stages of the archaeological process and for representing archaeological entitites. Nevertheless, visualization methods are used by less respondents for representing stratigraphic units and during the research stage.

3.2.2. Non-realistic Visualization

As with realistic visualization methods it is important to understand how non-realistic methods are used in the stages of the archaeological process and what kind of archaeological objects are mostly represented by them.

Table 3 illustrates the use of non-realistic methods both during the archaeological process and considering different archaeological entities.

Although there is (again) a significative number of non-responses, non-realistic visualization methods are used by about half of the surveyed archaeologists troughout the differente stages of the archaeological process and for representing archaeological entitites. Nevertheless, visualization methods are used by less respondents for representing

	Yes	No	N/R
Post-Processing of Archaeological Record	19	9	9
Analysis & Interpretation	21	7	9
Research	18	10	9
Dissemination	17	10	10
Artefacts & Finds	17	11	9
Stratigraphic Units	19	9	9
Structures	20	8	9

Table 3: *Use of Non-Realistic Methods*

artefacts and finds, and during the research disseminations stages.

Globally, non-realistic visualization methods are less used by the respondents than realistic methods.

3.3. Visualization Techniques

Responding archaeologists were asked about their use of the following visualization techniques: (1) *tables*, (2) *charts*, (3) *graphs*, (4) *maps*, (5) *colour mapping*, (6) *glyphing*, (7) *cutting/slicing*, (8) *2D drawing* and (9) *3D modelling*.

Table 4 illustrates the use of these visualization techniques by the respondents of this survey.

	Yes	No	N/R
Tables	24	6	7
Charts	19	7	11
Graphs	32	0	5
Maps	32	0	5
Colour Mapping	28	3	6
Glyphing	23	5	9
Sectioning	26	3	8
2D Drawing	31	0	6
3D Modelling	23	6	8
Other Visualization Technique	0	10	27

Table 4: *Use of Visualization Techniques*

The visualization techniques most used by the responding archaeologists are graphs, maps and 2D drawings. More than half of the respondents also use 3D models.

Further analysis of the responses regarding the use of 3D models resulted in the following: (1) on the one hand, 3D modelling is mostly used by the older archaeologists; (2) on the other hand, 3D modelling has a tendency to be more used by archaeologists that are associated to public institutions, rather than to universities.

4. Conclusions

The questionnaire regarding the use of visualization tools in Archaeology was answered by 39 archaeologists (37 valid

responses) from 6 different countries. And we consider that such a sample provides valuable indicative results.

The analysis of the survey data indicates that the responding archaeologists use, to some extent, computer-based visualization tools, with non-realistic methods being less used than realistic ones.

Moreover, the responding archaeologists still prefer the traditional visualization tools. Among the younger respondents there is even a greater preference for traditional visualization tools than among the older ones. This seems to be an important indicator and requires that visualization tool designers and developers must ensure an environment similar to the one archaeologists are traditionally used to.

Regarding the use of 3D models in the visualization of archaeological data the result of the survey raises two issues: (1) 3D models are mostly used by the older respondents; (2) 3D models seem to be mostly used by respondents associated to public institutions, rather than to universities. These issues should be examined more carefully, since 3D models are widely used to disseminate knowledge about archaeological sites among the general public.

References

[BIS11] BISSTO: Research - surveys and sampling, July 2011. URL: http://data.bolton.ac.uk/bissto/researchskills/research_method/strategies/surveys.htm. 2

[Kar11] KARCH M.: How to make forms, surveys, and quizzes in google docs, July 2011. URL: http://google.about.com/od/toolsfortheoffice/ss/\forms_googledoc.htm. 2

[LE07] LENGLER R., EPPLER M. J.: Towards a periodic table of visualization methods of management. In *Proceedings of the IASTED International Conference on Graphics and Visualization in Engineering* (Anaheim, CA, USA, 2007), GVE '07, ACTA Press, pp. 83–88. 1

[Mar00] MARTÍNEZ V. M. F.: *Teoría y Método de la Arqueologia*, 2 ed. Editorial Sínteses, Madrid, May 2000. 1

[Rob12] ROBERTSON J.: Likert-type scales, statistical methods, and effect sizes. *Commun. ACM 55*, 5 (May 2012), 6–7. 2

[SMI99] STROTHOTTE T., MASUCH M., ISENBERG T.: Visualizing knowledge about virtual reconstructions of ancient architecture. In *In Proceedings of CGI 99 (Canmore, June 8-Ű11). Computer Graphics Society, IEEE Computer* (1999), Society Press, pp. 36–43. 2

[SWMW07] SIFNIOTIS M., WATTEN P., MANIA K., WHITE M.: Influencing Factors on the Visualisation of Archaeological Uncertainty. In *VAST* (2007), Arnold D. B., Niccolucci F., Chalmers A., (Eds.), Eurographics Association, pp. 79–85. 2

[ZCG05] ZUK T., CARPENDALE S., GLANZMAN W.: Visualizing temporal uncertainty in 3D virtual reconstructions. In *VAST* (2005), Mudge M., Ryan N., Scopigno R., (Eds.), vol. 2005, Eurographics Publications, pp. 99–106. 2