Virtual 3D Reconstruction of the Kiafar Site, North Caucasus, Russia

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Abstract

The VR application in archaeology is one of the most rapidly developing sections of this discipline. This paper argues current conceptualisations of VR implementation in archaeology. While the mainstream efforts in the field are dominated by the notion of increasing realism of VR models, this approach regarding VR 3D models as thoroughly assembled replicas of reality is considered to be misleading and eventually dead-ended. Alternative conceptualisation of VR as a two-step interpretation (at the data recording and data processing stages), rather then representation of initial archaeoreality is introduced. VR is proposed to be regarded as a duo system, involving a perceiving subject and an object of knowledge. In order to exist and function, this system engages an active and mobile researcher freely negotiating with and interpreting archaeological data through a medium – a VR model. The concept of realism, as well as authenticity and faithfulness of generated models, is suggested to be understood as integrity and homogeneity of initial data organized in a virtual environment.

These theoretical underpinnings are illustrated by the Kiafar project, a pioneering case-study in Russian archaeology. Its significance is confirmed by the role Kiafar plays for research, preservation and popularisation of Russian historical heritage.

Key words: VR, 3D model, conceptualisation, archaeoreality, virtual environment, non digital data

1. Introduction

The last decade has been marked by a significant rise in interest in virtual 3D modelling among the archaeological community. Some of the potential of the impressive development of virtual technology has been explored in a constantly widening range of its application in archaeological projects and case studies and presented in a number of weighty publications (Forte 1996, Earl 1999, McCullagh et al. 1999). These enthusiastic efforts were mainly concentrated on the realism of modelling, or model authenticity. This resulted in the fact, that while the presentational power of 3D models is indisputable, their contribution to archaeological interpretation is still problematic. The lack of theoretical underpinnings of existing VR models leads to a contradiction between what *we think* a model is, and what does it *truly represent*. In this paper, I intend to focus briefly on the conceptual shortcomings of VR modelling of archaeological sites. The alternative conceptualisations of VR and approaches to modelled data are to be discussed.

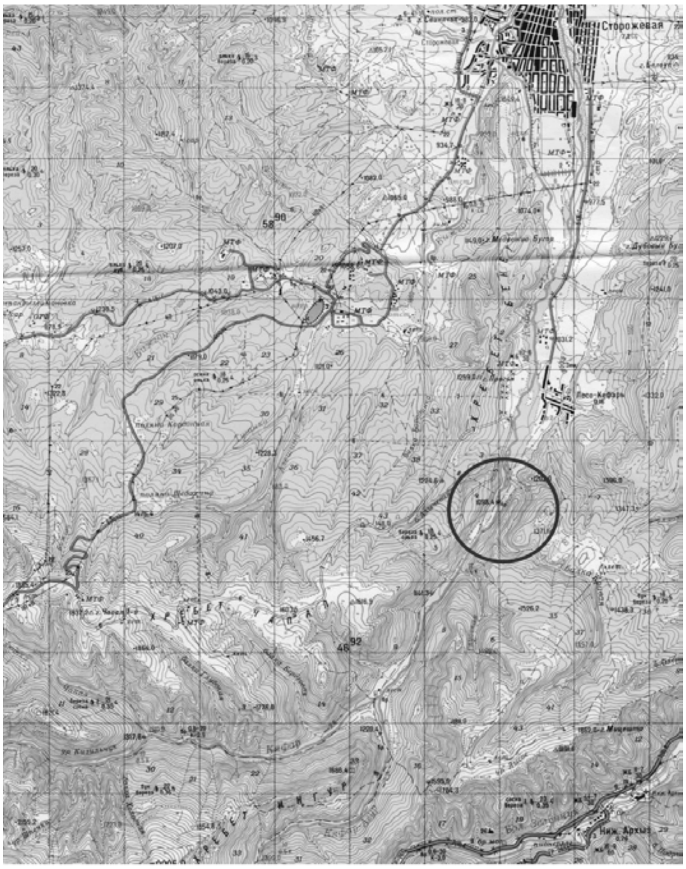
Another issue of enormous significance to be taken into consideration at this point is the demand for initial data from which models are produced. The currently existing digital survey data archives containing satellite images, GIS databases, digital terrain models (DTM) and other types of spatial data are fragmented. This makes the utilisation of paper copy plans, drawings, hand-managed measurements and photos that have been collected over numerous decades, inevitable. In Russia, where there are no digital data archives at all, and the survey data is stored in paper form, this problem is especially vital.

A brief outline of the Kiafar project will be given in the presented theoretical framework, and the potential of data that was initially not digital, nor was it ever supposed to be digitally processed and analysed for the creation of 3D virtual models will be demonstrated.

2. VR – seeking new approaches

The concept of VR has been recently discussed to a great extent in a number of publications (see Gillings 1999). Instead of returning to these debates here (which would take a lot of time), I intend to focus your attention on the nature of the interrelationship between *reality* and *virtual reality*. The mentioned trend, manifested by VR case studies to make produced models as realistic as possible, originates from a misleading concept of VR being a kind of reality replica (Gillings 1999, Burton et al. 1999). According to this notion, the more realistic, or authentic, the replica seems to be, the less it is considered to be a fake. Thus, the ideal VR model is supposed to be indistinguishable from what it represents. The paradox is, that the most detailed and carefully constructed model will never match the original. At first glance, the explanation of such a phenomenon lies in the specifics of an object of archaeology as a discipline. An archaeologist deals with *traces* of reality that have been transformed by time, and can be described as *archaeoreality*. This implies a notion of multiple interpretations caused by individual characters of perception. It brings us to the thesis, that any VR model is an interpretation, rather than a representation of reality.

Further on, it poses a question: is what we interpret, or better say - model, reality? The answer is negative. In fact we interpret (model) an interpretation itself. A VR model is nothing more than data processed with a given algorithm. The data we extract from reality through perception, recognition and, finally, description can be expressed with the term meta-reality, or hyper-reality. The process of modelling this data (hyper-reality) introduces also a second level of interpretation. The resulting model reflects an in-



○Kjafar site area.

Figure 1: Kiafar site region map in 1:100,000 scale.

dividual (unique) interpretation of hyper-reality that was carried out by computer processing algorithms.

The nature of VR as an interpretation model involves two main elements: a perceiving subject (e.g. researcher) and an object of knowledge (e.g. modelled archaeoreality). At the production stage the link creator – data, sustains this dual system. When an external viewer is engaged, one substitutes a model creator, while a model becomes an object of knowledge itself. From the other side, a model is a medium of interaction between a perceiving researcher and recorded archaeological data. The productive interaction can be executed through two main channels: analytical functions of a model and/or visual perception. To support the first channel the model is to be an integrated part of a GIS analytical environment, as for the second, it is based on the notion of a researcher being actively involved within a model. The dynamic model generated by the VRML technique, with a mobile viewer (engaged person) navigating freely through a modelled archaeoreality environment, seems to suit the requirements. Any pre-programmed set patterns of viewers dislocation and movements are to dramatically decrease the potential of a model.

The last theoretical issue I would like to examine is the mentioned concept of realism of a model. We must realise, that ever increasing visual sophistication does not bring a model closer to reality. Realistic, in this case, does not mean real. Rather then spend time and costly efforts on stunning but static re-constructions, featuring ever unparalleled visual details, I would propose to concentrate on an alternative notion of realism. In the mainstream of formulated conceptual underpinnings the term realistic is referred to the initial data. Its integrity and homogeneity, along with volume and quality, provide true realism. Thus, the demands for authenticity and faithfulness applied to a model are incorrect, and to be redirected to the initial raw data.

Figure 2: An extract from Kiafar's topographical plan.

While working on the (for Russia, pioneering) project to virtually model one of the pilot sites of medieval time in the North Caucasus, these theoretical issues have been evoked. The low project budget made digital surveying equipment unaffordable. In this case, the initial spatial data was carefully manually obtained with simple optical theodolites and recorded and stored in a paper form. With the integrity analysis carried out through the data, it was considered sufficient for creating a preliminary virtual model.

3. The Kiafar project

3.1. Background

The Kiafar site is situated in the Karachai-Circassian Republic in the Russian North Caucasus. In the first and early second millenia AD the Iranian-speaking Alans inhabited the region. By the 10th century AD several dozens of strongholds had emerged there. Nearly all of them were equipped with complicated fortifications, well thought-out and adapted to the environment. The well-organised Kiafar township is the largest of the fortress towns of the period between the 10th and 12th century AD. The site with all its 1.8 km length is stretched along the narrow Kiafar-Argun river valley, and lies on the mountain ridge. The highest point of Kiafar, the peak, is some 180 m above the bottom of the valley, totalling approx. 1200 m above the Baltic sea level (figure 1).

Kiafar was chosen as a pilot site for 3D modelling and subsequent visualisation for the following reasons:

1. This site can boast a comprehensive survey database indispensable for adequate modelling. The archaeological expedition headed by Irina Arzhantseva has succeeded in producing a detailed 1:500-scale topographical plan with

Figure 3: Fortification wall.

Figure 4: Panorama of Kiafar site: mountain ridge completely covered with forest.

a 1m contour line interval. Providing detailed relief data, the plan also shows some 200 surviving structures as well as numerous landscape peculiarities (figure 2).

2. The remains of architectural structures at the site are very well preserved, which allows for a minimum of conjectures in the course of modelling (figure 3).
3. Kiafar, allegedly the capital of the Western Alans or a residence of a powerful prince, included all sorts of household structures, sanctuaries and fortifications. A 3D model of such a complex site provides rich opportunities for an analysis of both the juxtaposition of architectural structures and their interplay with the micro-regional landscape.
4. The mountain ridge, where the site is located, is covered with woodlands (figure 4). This fact hinders the visual estimation of the site and the degree of man-inflicted changes to the landscape. The interactions of the ancient town population with the environment, their use of the landscape and their adoption patterns can only be analysed virtually. Also, and this is also a vital issue, the same is true of the aerial and space survey. The decoded satellite and aerial data are hardly informative at all.
5. Last but not least, the Kiafar site was selected for 3D modelling to prevent its ultimate loss.

The 3D model enables us to achieve a virtual conservation of the site, and estimate and monitor the great damage done to the site with the passage of years. The information extracted from the model would help to elaborate a set of methods for the preservation of Kiafar and other archaeological sites in Russia. An adequate model of Kiafar and the adjacent territories could contribute to the creation of an archaeological national park in the North Caucasus.

2.2. Software requirements

At present a wide range of commercial GIS/CAD software products are available at constantly decreasing prices. It makes the final choice a matter of budget opportunities and particular preferences. Along with our notion to integrate the VR model into the analytical GIS environment, we were seeking a software tool with an extensive set of both GIS and CAD functions, and failed to find one. Most GIS products lack a powerful COGO engine indispensable for the purposes of sophisticated detailed 3D wireframe modelling. CAD software offers much more flexible modelling instruments and opportunities, however its analytical potential is far from being sufficient.

In the end we decided to use Autodesk AutoCAD 14 as a 3D modelling tool. The digital terrain model was created in its module EaglePoint Software LANDCADD 14, which is specially designed

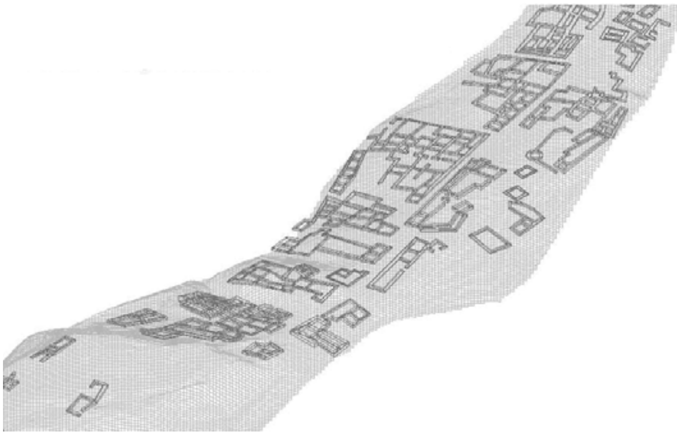


Figure 5: The remains of the buildings (3D) on the grid. Scaled to region 230x125 m.

for shaping 3D terrain surfaces, while the Autodesk 3D Studio MAX and Adobe Photoshop 5.0 were proposed for rendering the wireframe model. Budget limitations have predetermined the choice for ArcView 3.1 as a GIS tool. According to the "GIS and archaeology" survey conducted a few years ago (Moscati 1999) these software solutions seem to be the most popular for projects carried out within the framework of research institutions.

3.2. Model construction

The Kiafar project consists of a number of elements:

1. the DTM of the site and the adjacent area,
2. the models of the surviving architectural structures of the site,
3. the vegetation map of the Kiafar area,
4. the hydrological map,
5. the geological map,
6. the soil map and
7. the relatively extensive database of photos, video clips, textual descriptions.

All of these elements are to be integrated in an interactive GIS environment with VRML and HTML support, providing a viewer instant access to all types of data simultaneously. The viewer is encouraged to freely seek his position, and navigate anywhere within Kiafar's virtual environment (or archaeoreality), and explore the relative database organised with full hyperlink, cgi-script support. One of the key concepts of the proposed virtual reality is to eliminate any pre-programmed patterns of the viewer – constructed environment interactions and his engagement in the process of negotiation and interpretation of the modelled archaeoreality.

To date, we have completed only two stages of the Kiafar project, i.e. we have generated the digital terrain and architectural structures wireframe models. The 1:500-scale hardcopy of the topographical plan with a 1m contour line interval became the basis for the DTM. The contours, after being digitised, resulted in a set of polylines, that were used to create a triangular irregulated net (TIN). The TIN in turn served as the base for an elevation grid with 1x1 meter cells. We consider such a grid resolution the most appropriate for the needs of the relief model, because a less detailed elevation grid would not reflect all the peculiarities of the micro-relief, while a denser one would offer no substantial additional information. The 1x1 meter celled grid coincides with the original topographic plan of 1m contour line intervals.

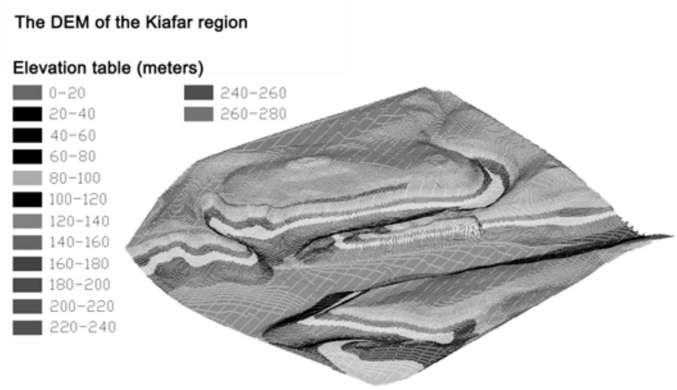


Figure 6: The DEM of the Kiafar region, 4x4 km.

Unlike the TIN, such an elevation grid is a regular one. Hence, the architectural structures under consideration can be adequately placed in the DTM (figure 5).

After the final DTM was completed, the problem of possible errors in the course of modelling arose. The possible voids in the initial contour lines data could lead to artificial non-existent slopes/elevations, and various holes may appear on the DTM. In order to check this, we generated contour lines on the basis of the elevation grid and compared them with those of the original plan. Beyond expectation, all the virtual and original contours coincided.

At the next stage 3D wireframe models of all the architectural structures were created and referred to the DTM.

The resulting wireframe model of the Kiafar township was merged with that of the local micro-region based on a 1:100,000-scale map covering 16 square km (figure 6).

Though the project is far from being completed, even this preliminary model contributed significantly to the intra-site spatial analysis, enabling us to re-estimate the vertical juxtaposition of structures, examine the zone structure of the site, single out compounds and types of buildings within them and discriminate between residential, administrative and economic areas of Kiafar. The true potential of the virtual environment is to be exploited with a final model.

4. Conclusions

The VR application in archaeology is one of the most rapidly developing sections of this discipline. At the same time the mainstream efforts are dominated by the notion of increasing realism of details. I consider this approach to VR as thoroughly assembled replicas of reality to be misleading and eventually leading to a dead-end. Alternative conceptualisation of VR as a two-step interpretation (at the data recording and data processing stages), rather than representation of initial archaeoreality is introduced. VR is proposed to be regarded as a dual system, involving a perceiving subject and an object of knowledge. In order to exist and function, this system engages an active and mobile researcher freely negotiating with and interpreting archaeological data through a medium – a VR model. The concept of realism, as well as authenticity and faithfulness of generated models, is suggested to be understood as the integrity and homogeneity of initial data organised in a virtual environment.

These theoretical underpinnings are to be implemented in the Kiafar project, a pioneering case study in Russian archaeology. Its significance is confirmed by the role Kiafar plays for research, preservation and popularisation of Russian historical heritage.

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