Pathways, Perception and the development of Place: Computational approaches to movement and perception of landscape in prehistory

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ABSTRACT

Traditionally, analysis of archaeological landscapes has drawn on two separate theoretical traditions. Functionalist explanation in the tradition of Renfrew (1973) emphasises general patterns in economic and social structures, and the development of formal methods. Approaches informed by phenomenology, such as those by Tilley (1994) or Thomas (1999), emphasise human-scale experience of landscape and the 'constructed' nature of space leading to, for example, suggestions of 'circular landscapes' in the Neolithic of Britain (Bradley, 1998). In the last decade, approaches that draw on both of these have emerged in the context of GIS-based landscape studies. One such area has been visibility analysis (e.g. Wheatley, 1995; Exon, Gaffney, Woodward & Yorston, 2000) in which formal methods for analysing visual characteristics of landscape build up from an understanding of perception at the scale of individual human actors.

Although successful, most of these have dealt with visibility from static locations and ignored (or minimally considered) the effects of movement. This project centres on the investigation of movement and perception within archaeological landscapes; intending to study dynamic changes in visual envelope afforded active, mobile agents. By comparing archaeological features with these changing patterns of visibility, the aim is to form hypotheses regarding potential modes of interaction with and hence development of the continually evolving cultural continuum that is landscape.

Patterns of changing visibility are being further investigated by incorporating some elements of three dimensional visualisation in order to take account of (for example) colour, lighting and atmospheric models; key factors which affect human perception of space. These issues are particularly significant in the context of later Neolithic Britain, in which a series of monumental forms seem to have developed that formalise aspects of movement through landscape (e.g. cursus monuments, avenues). Consequently, the research focuses on later Neolithic landscapes including Avebury and the Dorset Cursus complex.

This paper presents some of the methodological and technological developments to date, including the development of a computational framework for the investigation involving the fusion of a Geographic Information System and three-dimensional technologies. In addition to the development of approaches to viewshed analysis within the GIS, the use of a three-dimensional modelling package to produce rendered views from the GIS will also be discussed and some preliminary results will be presented. Image processing techniques for the analysis of these views with also be discussed. Another aspect of the proposed framework is the use of a gaming engine to provide an interactive, dynamic three-dimensional interface linked to the GIS and rendering suite.

1. LANDSCAPE AND VISIBILITY

It can be argued that any particular landscape at any particular point in time can be seen as a snapshot of the complex cultural continuum of interaction between humans and their environment; understandings of landscape being fluid and subject to reinterpretation through time with origins which may date back in one form or another to notions in earlier prehistory of pathways and places of the sorts described by Ingold (1980). The formation of cultural landscapes and the physical remains which we study can therefore be seen as a function of this interaction, interaction which has at its core the notions of movement and perception, humans being highly visually attuned, mobile actors. A broad theoretical discourse regarding the nature of this human-landscape interaction has developed within archaeology (e.g. Scarre, 2002) with focus on studies involving human experience (e.g. Bradley, 1998), drawing in part from functionalist explanation (e.g. Renfrew, 1973) and latterly, phenomenological approaches (e.g. Tilley, 1994; Thomas, 1999); this discourse is supported by various analyses of the visual characteristics of landscape (e.g. Wheatley, 1995; Exon, Gaffney, Woodward & Yorston, 2000) which have demonstrated that visibility can be seen as a significant factor in the development of cultural landscapes at various places and times.

2. GIS-BASED VISIBILITY ANALYSIS

While studies to date have produced significant results and added to our corpus of knowledge, there are limitations to the kinds of models used; any such model used will be an abstraction, an approximation of a given situation in which assumptions are made, some more robust than others. The most common approach to visibility analysis involves the construction of viewsheds from observer locations within a study area resulting in a map showing visible areas and obscured areas (e.g. Exon, *et al.*, 2001). This uses a purely mathematical model of space whereby if it is possible to draw a vector between two points, there is a line-of-sight, otherwise there is none. While informative, such approaches do not take into account factors such lighting, colour or other conditions in the environment which affect visibility. Another assumption is that the underlying elevation model can be treated as an accurate representation of reality; uncertainty regarding elevation can have a dramatic effect on visibility analysis, so can the presence or absence of vegetation, yet

most GIS-based studies have completely ignored these factors. Indeed, the amount of processing power needed has had implications for such analyses, where the sheer volumes of data to be processed have necessarily led to necessary simplification of models used. Viewsheds are invariably calculated from static viewpoints, another simplification of reality; whilst informative, the assumption has been that it is direct and static lines-of-sight to/from archaeological sites or other landscape features which are important rather than broader trends in patterns of visibility associated with moving around or through a landscape.

3. A MULTI-FACETED APPROACH

This project aims to draw on theoretical developments in landscape studies, concerned with concepts such as movement through and perception of landscape (e.g. Cummings, 2000; 2002; Whittle, 2003) and investigate two study areas using a computer-based methodology capable of taking into account some of the issues previously raised, a fusion of GIS-based analytical functions and three-dimensional visualisations to take make the most of both technologies. The study areas, the Avebury region (Wilts.) and the Dorset Cursus (Dorset) environs, have been chosen as they both contain monumental architecture from the Neolithic with strongly linear forms, possibly related to much older ideas concerning movement of some kind. This paper presents the methodology under development to date to facilitate the investigation of the study areas.

Computer hardware has improved in recent years to such a degree where what would have been considered impossible at the turn of the twenty-first century is now considered run-of-the-mill and it is possible to build powerful systems capable of the sorts of analytical work and visualisations necessary to undertake such investigations. This has also made advanced methodologies such as Lloberra's (2001) Total Viewshed and Fisher's (1992; 1994) probabilistic viewsheds much more accessible, with desktop computers capable of performing complex routines in a matter of hours or days rather than weeks or months; modern servers and workstations offering even more processing power. Software has advanced too, with 3D modelling packages now capable of generating millions of individually unique trees of a chosen species and providing real-time lighting effects; again, not running on dedicated graphics workstations but desktop personal computers.

The proposed technical methodology involves a number of components integrated into a system aimed at tackling the issues outlined above. While such an approach offers a potential improvement with respect to a more robust theoretical framework, it is still an abstraction of a series of real-world phenomena which makes a number of explicit assumptions; a model. The first major assumption is that perception is limited solely to visual perception; other forms of stimuli are not currently incorporated. This is not considered a limitation of this project as use of purely visual characteristics is common to all analyses based on the concept of visibility; indeed the theoretical model of visibility used in many GIS-based analyses is even more restricted, using a purely mathematical basis for vision which cannot adequately account for a range of visual characteristics of landscape, as previously described.

The currently proposed system architecture is shown in Figure 1. The system comprises three main components: GIS, a visualisation suite and a real-time interactive interface. This is supported by an additional component capable of image analysis.

4. GEOGRAPHIC INFORMATION SYSTEM

The GIS will be used for creation and maintenance of datasets and undertaking analyses such as visibility analysis along paths through the study areas. In addition to producing a range of viewsheds from archaeological sites and other features, the GIS will be used to investigate broader patterns of visibility afforded an active observer moving around the landscapes of the two study areas. The idea of a dynamic viewshed can be used to describe this notion of a changing viewshed afforded an active observer. The idea behind this is that there may be changes in these broader patterns associated with the development of the landscape through time. For example, preliminary work at Avebury (Cripps, 2001) tentatively showed that the area to the western end of Longstones Field, a place of significant prehistoric activity (Gillings *et al.*, 2000), is associated with a dramatic change from one visual envelope to another; indeed a path through the region was tentatively described in terms of discreet sections, discernible by their visual characteristics (Cripps, 2001).

5. THREE-DIMENSIONAL MODELLING

Results from the GIS-based visibility analysis can then be replicated and compared against those produced using the visualisation suite, capable of the sorts of environmental visualisations needed to investigate environmental effects such as lighting, vegetation and colour. In this way, the three-dimensional reconstruction is placed within an analytical framework, a meaningful context, of the sort advocated by Gillings (1997). The suite will be used to output a variety of rendered images and animations for subsequent analysis in the supporting image analysis component and for comparison with images gathered during fieldwork. The environmental evidence, having been imported into the GIS, will be used to populate the landscape with appropriate species of vegetation.

6. IMAGE ANALYSIS

One way of investigating views is to quantify them in a similar way to any other spatial dataset, allowing us to ascertain if there are certain attributes to views which give them a particular feel. A particular area of interest is the hypothesised circularity of many landscapes and rendered views and photographs will be used as source material for this quantification. There are a number of factors which may give a sense of circularity, including elevated surrounding terrain or, conversely, completely flat surrounding terrain. Perception over distances becomes particularly important with second and subsequent horizons, which may be a significant distance away.

This quantification will be undertaken using a semi-automated procedure, whereby certain image metrics can be obtained using a standardised approach, allowing for comparison between landscapes and viewpoints.

7. REAL-TIME INTERACTION

The GIS results will also be accessible by means of a dynamic interface capable of providing the user with an interactive view of the data. This will be built around a games-engine with a published API. The idea behind this component is to provide a dynamic interface to support further investigation of movement through the study area.

8. AN INTEGRATED APPROACH

Components being evaluated include ArcGIS and Grass for the GIS aspects of the project and Vue 5 Infinite for the visualisations. ArcGIS has significant data modelling capabilities, especially with the extensions such as the Tracking Analyst, while Grass GIS is highly efficient for processor intensive tasks such as viewshed calculations. Yet to be evaluated are games engines which make use of OpenGL rather than Microsoft's DirectX, suitable for taking advantage of the advanced graphics architecture of the Apple Macintosh G5 (see Debevec, 1998, a version of which now runs in real-time on the G5). Data will be shared throughout the system components, either by means of dynamic links between applications or by procedures to ensure the same version of datasets is in use by all system components. Interoperability will be accomplished using a combination of Visual Basic, Python and other scripting languages as required, mainly passing information regarding position and orientation of the observer and metadata regarding datasets.

This research is currently in its early stages with considerable work still to be done relating to technical developments of the system and subsequent investigations using the system. It is anticipated that systems design and implementation will be completed during 2005, with 2006 scheduled for detailed investigations of the two study areas.

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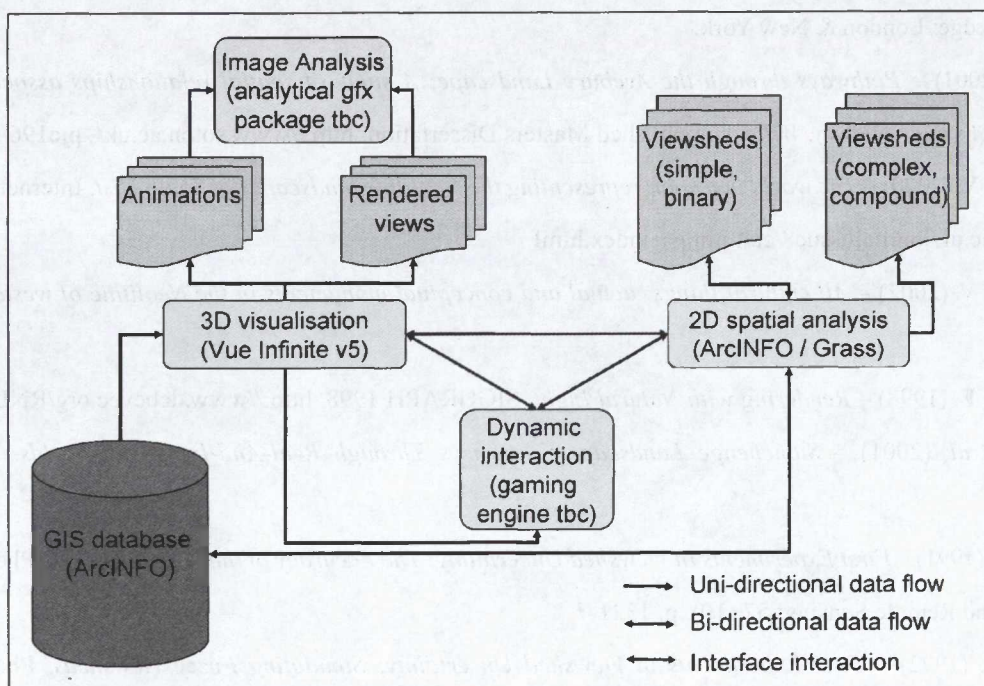WHITTLE, A. (2003) – *The archaeology of People; Dimensions of Neolithic Life*. Routledge, London.

FIGURES

Fig. 1 – Overview of systems architecture.