Shadow of the Stanford Bunny

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1. INTRODUCTION

The visual characteristics of a landscape are difficult, and controversial to define. Yet the European Landscape Convention, requires an "objective" view of 'landscape quality' to determine where special protections should apply. In an attempt to provide objectivity, studies have sought relationships between scenic quality and "metrics" (measures of the arrangement of landscape features), for example:

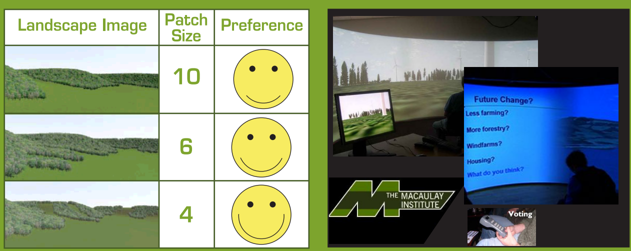

Figure 1: Respondents are asked to vote on how much they like a scene. This is then correlated with landscape metrics.

Planning processes are dependent on cartographic views for a summary. However, scale and displacement forms of the Modifiable Area Unit Problem (MAUP) occur when modelling landscape value as it appears from a particular viewing point, using data from a flat map. Perspective influences the geometry and scale at which different parts of the map data are seen, and topology is affected when landform masks part of the data. For example, a polygon on a map may be classed as heather, but the segment visible be predominantly rough grassland. We present a method for automatically analyzing data in perspective view, with an example application to 'landscape quality' assessment.

2. VISUAL TOPOLOGY

There is evidence that people naturally perceive topological relationships and use them when forming their opinions about landscape. Linguistic descriptions of landscape are grounded in topological concepts, including relationships which only exist as perceived from given viewpoints for example 'Noonmark mountain' (Keen Valley, YN, USA). While there areas an established taxonomies of topological relationships which describe the kinds of links possible, as used for ecological landscape metrics, the same has yet to be developed for visual adjacency and applied to visual aspects of landscape.

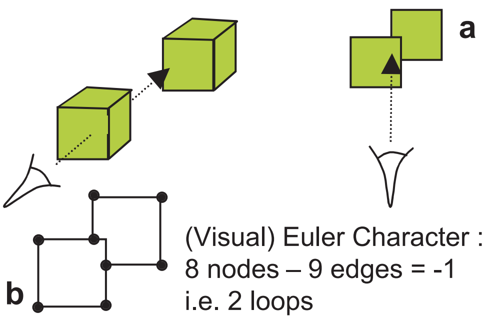

Figure 2: Visual Topolgical Relationship "Overlap" (a) and Visual Euler Character of resulting graph (b).

Sang, Miller and Gold [1] extends the concept of a Euler Character and Egenhoffer and Herring's [2] 9-Interesection model to visual relationships (Fig2). In particular this raises the concept of the horizon-shadow edge, the apparent edge between parts of a view where one object masks another.

3. HORIZON-SHADOW EDGES

Purcell et al. [3] and Yang et al. [4] demonstrate (on the 'Stanford Bunny' ray tracing and splatting algorithms for shadow casting which in principle could be extended to build Horizon-Shadow edges. However 'the Stanford Bunny' has relatively few potential horizon-shadow edges due to self occlusion, to do so efficiently in a landscape analysis context is more challenging.

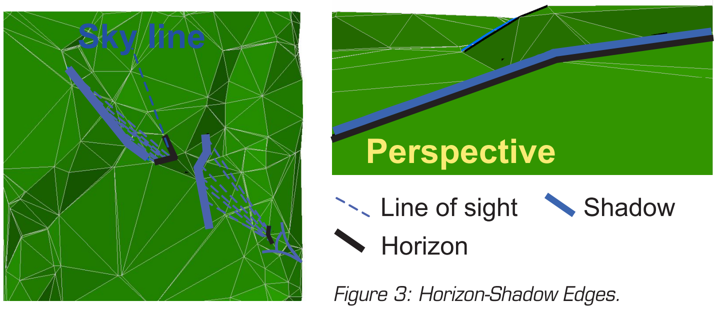

Figure 3: Horizon-Shadow Edges.

Horizon edges can be detected efficiently on triangulated terrains by comparing the vector normal of each triangle, with the viewing vector. This edge can then be projected to "screen" coordinates to find the position of the horizon in the view (Fig 3). Providing the TIN is traversed such that nearer elements are always processed first, a "chain" of such edges can be built up to form the over all horizon.

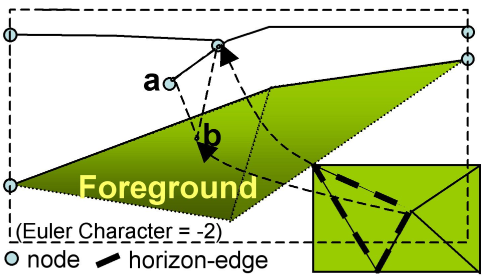

Figure 4: Connecting Shadow edges in Perspective View and the Euler Character of the resulting "Horizon Graph".

If an element is found to intersect a horizon (line 'a-b' Fig 4), at that stage information about both the foreground (horizon element being intersected) and background (shadow element being projected) is known. Since the relationship between background and foreground elements can be one to many, recording a pointer to the relevant horizon element as an attribute of the shadow element is an efficient method to store this information (Figure 3). The TIN is then traversable from background to foreground along lines of sight and horizon-shadow boundary graphs can be extracted along with their attributes.

4. DYNAMIC UPDATE

The utility of studies relating preferences and landscape metrics is currently limited by the time required to analyse the corresponding views. Preference data is only collected for a few key viewpoints, and selecting key view points is therefore controversial. The horizon-shadow calculation needs to be sufficiently dynamic to allow landscape metrics to be calculated in real time.

In most cases, the new shadow will be near the old shadow for an incremental change in view point, so considerable efficiencies should be possible by incrementally "moving" the horizon shadow edge, using the adjacency information the quad-edge TIN structure affords, and testing it against the new view point.

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[1] Sang, N., Miller, D., Gold, C., subm, Visual Topology : Extending the Nine Intersection Topological Model to Support Analysis of Visual Relationships; [2] Egenhoffer, M., Herring, J., 1990, Categorizing Binary Topological Relations Between Regions, Lines and Points in Geographic Databases Technical report, Department of Surveying Engineering, University of Maine; [3] Purcell, T., Buck, I., Mark, W., Hanrahan, P., 2002, ACM Transactions on Graphics; [4] Yang, R., Guinnip, D., Wang, L., View- Dependent Textured Splatting, http://vis.uky.edu/~wangl/Research/VDTS/VDTS/VDTS.pdf