G184C – Geographic Visualization
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Landscape animation design: testing the landscape experiences elicited by different camera trajectories

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Introduction

Landscape visualization is evolving technically and conceptually, stimulated for example by the growing interests in preserving the visual quality of landscape. Moreover, in the broader context of geographic visualization, there is a fundamental interest in finding new and better ways to represent geographic information, even when a high degree of realism is required. In a more artistic framework, landscape visualization might constitute a new support and a new content for expression. Whether a practical tool for conveying ideas, or an instance of scientific visualization, or a device for artistic expression, landscape visualization seem to address and draw from the fundamental importance of the geographical concept of landscape.

Such diverse roles for landscape visualization needs to be supported by a theory that links all the different aspects of landscape experience, from spatial knowledge to aesthetics to sense of place, within a common context of landscape information. In fact it might be argued that the three aforementioned aspects depend mainly on the information available in the landscape (e.g. the depth cues of 3D layout, or the pattern of the ground textures, etc.). Since the appreciation of landscape is mostly developed in time, it is also important to know about the gradient (or rate) at which such information is available to the viewer. For example, when a valley is revealed behind the crest of a ridge, it causes a sudden increase in the available information (i.e. due to increased visible area), which is an aspect of time. This in turn impacts on the experience of landscape.

Such theory linking landscape information to landscape experience can be applied to develop design guidelines for landscape animation. The objective is to find out what are the controlling variables that make a fly-by more effective across the spectrum of landscape experiences. Realistic visualization is chosen here to produce a largely controlled environment that on the other hand resembles realistically the real world. Animation is needed instead to represent information gradients in time, which is the second dimension of landscape information.

This experimental study is aimed at determining if the variable of camera elevation can be considered as a control on landscape experience. In other words, the hypothesis is that a camera that follows closely the shape of the terrain elicits different reactions than a camera that flies high above the terrain in a uniform trajectory. This is considered as a topical case that might indicate the relevance of camera elevation as a design control variable in landscape animations.

This study is part of the research contributing to the Master Thesis of the author, and it constitutes the first exposure to testing for the project ideas. Therefore it should be considered as a pilot study that is mainly aimed at testing the experimental procedure, and which provides data only in limited quantity, mostly useful to consider the problem with some sort of supporting, instead of fully conclusive, evidence.

Methods

The investigation on the altitude of the camera as a variable of landscape experience required a particular experiment design. The experiment was a between-cases design with only two conditions, the first constituted by a camera following closely the profile of the ground (see Figure 1), and the second constituted by a camera flying along a uniform trajectory above the ground (see Figure 2).

Figure - Condition 1, camera following the terrain. The graph shows the profile of the ground and the profile of the trajectory of the camera on top.

Figure - Condition 2, trajectory uniform over the terrain. The graph shows the profile of the ground and the profile of the trajectory of the camera on top, in this case a straight line.

The participants were a total of 14 graduates and undergraduates (11 males and 3 females) from several departments on campus and were randomly assigned to the two conditions. One subject was discarded after the test for previous exposure to the contents.

The choice of the two conditions is justified by an attempt to isolate the extreme cases in which the camera trajectory has a particular relationship with the profile of the ground: in other words, the two conditions represent a camera having respectively direct dependence on the ground profile and complete independence. In turn the degree of dependence on the ground profile was assumed to be the best characterizing aspect of the vertical motion of the camera on the landscape, and therefore it was hypothesized as the source of most variation in landscape experience.

In terms of landscape information, the elevation of the camera is a complex variable comprising several components, which for example define the total viewable area (viewshed) and the amount of visible detail on the ground. From this point of view it was not claimed that camera elevation was a fundamental variable: rather it was considered convenient to make it vary, in turn affecting the subordinate landscape measures of information (e.g. viewshed, etc.).

The animations were developed using the software World Construction Set (WCS) version 3, by 3DNature, a Geographic Information System that produces realistic landscape visualizations from terrain data. The data used in the experiment were the digital elevation model (DEM) of Santa Catalina Island, provided by Dr. Bill Bushing formerly at Santa Catalina Island Conservancy. The modeling procedure involved the definition of the landscape parameters of Santa Catalina Island in WCS: although I aimed at making photorealistic images, a more simplified approach was preferred to a complete ecological replication of the original landscape. In practice only three types of land cover constituted the ground model and were distributed in distinct altitude bands. This was specifically done to control the amount of complexity in the landscape, although the vegetation variables as a whole were not manipulated in the experiment. The discussion of more specific issues in landscape modeling goes beyond the scope of this document. Figure 3 shows an example of a high detail, high-resolution visualization of the island using the final model parameters.

Figure - Photorealistic rendering of Santa Catalina Island using final landscape model parameters

Figure The study area on Catalina. The camera trajectories approximately correspond to the line connecting the center of the circle and the small cross

For both conditions I chose the same area on the island (see Figure 4), in particular defining the same trajectory in plan view (total length = 2.94 Km). The most important keyframes were digitized and then edited manually one by one to make the trajectory reflect the ground profile. In particular the terrain-following animation required a careful definition of the elevation of each keyframe at approximately a constant height of 25 meters from the ground. This operation could not be fully automated for difficulties in digitizing on a perfectly straight line at the required sample interval. The high-no-terrain-following animation had only two keyframes (start and end) at the same altitude. Both animations were composed of 660 frames (a total of 22 seconds of playback at video speed of 30 frames per second). The objective was to cover a large area incorporating great variation within the 22 seconds of playback, therefore the resulting camera speed was high (481 Km/h). The frames were calculated individually at the resolution of 320x240 pixels and then assembled by an animation utility called VideoMach (version 2.4.0) that produced the final AVI (Windows Audio Video Interleaved) file. The main tradeoff consisted in balancing the image quality with the playback speed. Unfortunately higher resolutions systematically resulted in a slow and irregular playback, so that there seemed not to be a better and viable alternative to low-resolution images. Figure 5 shows a sample of the final animation frames for the two sequences.

The set-up for the experiment consisted in a 800 Mhz Duron laptop computer with a 14.1” LCD monitor and the software Scala by Scala Inc. for handling the full frame rate playback of the animations and the display of the information screens to present the experiment to the participants. The settings included a full screen playback, which was preferred to a smaller animation window for its better overall “immersivity”, although the drawback consisted in the rather pixelled look of the images.

Figure – Column left: Terrain-Following. Column right: High Altitude No-Terrain-Following. The frame number (row from top to bottom) is respectively 200, 400 and 600.

The participants were exposed for two times to the same animation (determined according to the condition) and then were requested to complete a questionnaire (see attached document) that was used to test several aspects of their landscape experience, including spatial knowledge, aesthetics, and sense of place, as well as to collect some data about their background. The testing strategy included sketch maps, open-ended questions, and close-ended Likert scale questions. In particular the main aspects touched upon in the questionnaire were:

- Externalized spatial knowledge about the landscape topography
- Externalized spatial knowledge about the camera trajectory
- Aesthetics: coherence, legibility, complexity and mystery of landscape, feelings as suggested by prospect-refuge theory, like/dislike of landscape and trajectory. Sense of place: character and quality of scenery
- Visualization questions: image quality, realism and relationship with the real landscape counterpart

The preliminary analysis of the data provided in this document includes only the statistical analysis of the 32 close-ended questions, based on a One-Way ANOVA analysis of the between-subjects design. For the qualitative questions (sketch maps, open-ended questions, etc.) only a general overview is provided.

Results

The questions regarding the spatial knowledge of the participants presented a wide range of responses. In fact the sketch maps of the landscape comprised schematic representations of the major topographical features as well as depictions of relief with an attempt to use contour lines. The accuracy of these representations also varies even if generally the correct broad pattern of valley-ridge sequencing has been captured. The profile drawings ranged from very simple diagrams of camera trajectory to accurate graphical descriptions of the varying topography along the direction of the animation. A couple of attempts were made to make perspective drawings instead from top-view maps.

Participants seemed in general to have detected the type of motion of the camera with respect to the landscape, describing the characteristics of the terrain-following and uniform trajectories according to the condition. The detection of the trajectory as a straight line in plan view seem to present more problems and more or less curvilinear variants have been presented. Other particularities include the detection of an unexpected variation in altitude in the uniform condition, and some cases of trajectories where the terrain-following behavior was detected only for part of the animation..

Table 1a and 1b show the results of the statistical analyses conducted on the close-ended questions, including descriptive measures (mean and standard deviation) and one-way ANOVA significance tests. The answers show in general a large standard deviation (from a maximum of 3.69 to a minimum of 1.17).

Question 14 (“During the animation I was curious about which part of landscape was about to be shown next”) was significant at the $p<0.1$ level (Condition 1 = 6.29 mean, 2.56 std. dev. - Condition 2 = 3.5 mean, 2.43 std. dev.), indicating a higher “curiosity” for the uniform trajectory than for the terrain-following trajectory. Question 30 (“I feel I know enough of that landscape to find my way around in it”) was significant at $p<0.05$ (Condition 1 = 7.29 mean, 1.7 std. dev. - Condition 2 = 4.83 mean, 1.47 std. dev.), indicating higher feeling of “knowledge” for the uniform trajectory animation.

The other questions, while did not reach significance (and this was in general expected considering the modest amount of participants used in the study) show a more or less consistent difference in mean across the two conditions. Question 4 is the summary question for aesthetic appreciation indicating the like/dislike for the landscape overall. The results show very close means and no significant differences between the two conditions. Question 8 indicates how the terrain-following trajectory was more exciting than the uniform trajectory, although significance was not reached. Question 12 addressed the issue of memory and the results indicate a tendency for the uniform trajectory to be easier to remember. Question 23 asked about the desire to know more about the landscape, and the means seem to suggest that the uniform condition elicits more of such desire. The other answers do not show large differences in means but it cannot be said that the majority of the answers indicate identity of landscape experience between conditions, even if further study may verify a similar tendency.

Discussion

The low number of participants employed in the test (13 compared to an estimated minimum of 30 for a full strength experiment) implies that no conclusive statements can be done with the results, and moreover that the lack of statistical significance for most of questions might be only attributable to that number. However some preliminary considerations can be made concerning general trends.

While the questions about spatial knowledge, and especially the sketch maps, need to be encoded in order for an accurate analysis, it appears clear the great individual variation in the accuracy of the answers. If a pattern seems to emerge is that the terrain-following condition prompts answers depicting the profile variation of the landscape. The encouraging accuracy of the results confirms that the sketch map is a viable possibility for testing spatial knowledge, even if the individual differences make it a difficult element for the comparison of the two conditions. Other conclusions will be possible with a systematic comparison of the answers to the other close-ended questions, in order to see if any correlations exist.

The focus of this discussion are however the close-ended questions. By comparing the means for the two conditions for all the questions some tendencies from the data seem to arise. The two questions that reached significance levels (<0.1 and <0.05 respectively) are suggestive of major differences in the two conditions. Question 14 asks about the curiosity related to the animation and the way the landscape that was about to be revealed constituted an interest. This question was originally thought as testing the degree of mystery (amount of information about to be revealed) in a landscape, and therefore the hypothesis was that an animation with a camera close to the ground would have generated more “curiosity” for the alternation of valleys and ridges continuously disclosing new parts of the landscape. The results seem to contradict this hypothesis by proposing an animation with uniform trajectory as generating more “curiosity”. A possible explanation might be that the viewing of a uniform animation predisposes the viewer to a different attitude of observation that results in a sort of preparation to a more prolonged exploration. This explanation would link “curiosity” not strictly to how much landscape is about to be revealed (a more landscape information-based interpretation), but rather to the attitude of observation that naturally invites to more exploration.

Question 30 asks about the “feeling of knowledge” stemming from the impression of being able to navigate in the environment. The level of significance for this question indicates a fundamental difference between conditions, with terrain-following inducing less confidence in one’s ability to navigate than the uniform condition. This result can be interpreted by considering the better visual control on the surroundings that is offered by the high altitude trajectory. This should be compared to the uniform trajectory that instead offers continually changing and partial views (thus difficult to integrate) of the landscape. It is somewhat surprising that being able to look at the surface with higher detail (in the terrain-following condition) does not constitute a dominant element in determining the participant confidence for navigation. With hindsight the question seems to address the issue of the ability to develop survey knowledge rather than strictly navigating in the environment, and therefore the trajectory that offers more map-like views is preferred.

Four questions have shown not significant but still consistent differences in means (Q4, Q8, Q12, Q23). The general landscape preference question (Q4) suggests that camera trajectory (and height) might not be a strong factor in landscape preference.

Maybe it will be worthwhile to consider in a future study the way that the idea of landscape (and therefore our aesthetic appreciation of it) is formed, since it might be that it is not dependent on the way that it is observed. The effect of excitement of the terrain-following condition was expected: this relates to an idea of trajectory aesthetics that deserves to be expanded further in the future. The ease with which the landscape was remembered seems to support the previous considerations concerning the uniform (and high) trajectory being able to offer more map-like views that facilitate the development of survey knowledge of the topography. Finally Q23 on the desire for knowing more about the landscape seems to support the considerations made about Q14. The uniform (and high) trajectory seems to prompt more curiosity for knowledge and exploration, maybe an aspect related to the particular mode of observation that it suggests.

Conclusions

The test was an attempt to find interpretations of our experience of landscape in relation to two different observation conditions, namely a uniform camera trajectory high above the ground and a camera trajectory following closely the terrain. In the context of the Master Thesis of the author this constituted a first experimental verification of the approach to the design of landscape animations, investigating in particular the importance of the variable of camera altitude in our landscape experience.

For the experiment design I implemented two landscape animations, one for each between-subjects condition, using GIS software. A questionnaire was written to test the experience of landscape of the participants, focusing on the three related aspects of spatial knowledge, aesthetics and sense of place.

The results need to be considered of only indicative importance because the study was a pilot and, second, the number of subjects was below the target for attaining enough power for a complete analysis. However it was noticeable that already two questions resulted significant in an ANOVA test, indicating the superiority of the uniform trajectory condition in eliciting 1) curiosity in the part of landscape that was to be shown next in the animation and 2) feeling of knowledge related to the purpose of navigation.

The other questions suggest interesting patterns (although significance was not reached) such as landscape preference not significantly different in the two conditions, a more exciting terrain-following condition and an easier understanding of the landscape in the uniform condition, which was also considered more apt to elicit desire for more knowledge. These patterns seem to suggest several lines of differentiation between the two conditions, indicating that the design of an animation does matter in the type of the experience of landscape. The coding of the qualitative questions will provide further insight into the relationships between spatial knowledge, aesthetics and sense of place.

This study has provided useful information for developing hypotheses concerning our experience of landscape, a test ground for the experimental design in all of its aspects, as well as new problems to be tackled in analysis and theory formulation. This document has covered only a preliminary stage of the analysis, and some aspects have been left out, also following the pattern of results suggested by the descriptive statistics and the significance tests.

However the preliminary results seem to confirm that landscape animation design might influence our landscape experience, which, as illustrated above, varies according to the dynamics of our observation, and in particular camera elevation. This might open up new research directions.