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Human psychological response to landscape visual filtering in animation design

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Abstract

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Landscape is a valuable visual resource characterized by a specific degree of visual accessibility, which affects the exposure to the resource, human perception, and the outcomes of exploration. The motion along a trajectory allows the viewer to obtain a more specific view of the landscape, enhancing her information-seeking activity through a negotiation with the multiple visual aspects of the environment. As a conceptual tool, we consider this form of mediated exposure to landscape as a visual filter that selects only part of the landscape and temporarily hides the rest. This experimental study aims at verifying the hypothesis that the trajectory of the viewer on the landscape is a determinant factor in what perceptions and experiences are finally achieved. The objective is to show that the visual accessibility properties of landscape are not

isotropic, but rather patterned in landscape- and trajectory-specific ways. The experiment consisted of the development of six computer graphics fly-by sequences of three different landscapes (an agricultural plain, a narrow valley, and a steep hill), chosen to represent different terrain types. Each landscape was animated at low altitude in a terrain-following mode, and at high altitude in uniform mode. In a between-subject design, two groups of participants were asked to evaluate and self-report their perceptions, aesthetical insights, spatial knowledge and sense of place impressions on the three landscape in the two altitude conditions. The results of the experiment suggest that the visual landscape is patterned in terms of how accessibility determines experience, since there are differences in specifically predicted classes of responses. For example, the effect of mountain sheltering is felt only at low altitude in a sheltered terrain, and not in any other condition. The landscape seems to offer a different "face" (in the many dimensions that are considered) according to the trajectory of motion from which it is seen.

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Chapter 1

Introduction

The visual properties of landscape are a valuable resource that is manifest, for example, in the aesthetical reaction that most of us experience by viewing striking scenery. In fact, the current interest in visual impact and scenic quality indicates the increasing awareness of the community in landscape visual preservation. Acquiring the ability to access the resource of landscape is as important as the actual presence of the resource itself. Accessibility can be seen as the main factor of an epistemological quest that underpinned the evolution of psychological human-landscape relationships.

Landscape has been considered as *"a way of seeing"* (Lowenthal, 1961). This intrinsic quality might indicate that it is necessary to consider the process of observation as a conceptual basis for landscape. This is especially true when observation is considered as a process of selection of visual elements from the totality of the visible environment.

The interest in dynamic visualization can be related to the recent attempts to find novel and more effective methods of using increasing amounts of geographic data. Scientific visualization has brought forward the idea of *"seeing the unseen"*, an attempt to expose the hidden properties of data, and extracting their information content through visual representation (Buttenfield and Mackaness, 1991). Similarly, it is argued here that the *"seeing the unseen"* in a landscape context consists in increasing the degree of exposure of landscape to the viewer. The process responsible for exposing landscape is strongly related to the dynamics of observation: it involves the selection of hidden or fragmented visual elements from a series of views and their combination in integrated experiences.

It is suggested here that the trajectory of the observer on the landscape is critical in determining the characteristics of the experience of landscape. However, reasonably similar trajectories could suggest to us how comparable sets of landscape elements give rise to different experiences. Such difference will be patterned enough to help us determine their specific influence on the observer's perceptions. The interesting aspects of comparing the trajectories considered in this study is that they vary as a function of the form of the terrain. Such adaptivity is what characterizes our trajectories as terrain-based trajectories, instead of the other trajectories that are only an expression of independent movement in space.

Since the interest is placed on trajectory and not on viewpoint, the traditional approach of measuring preference using static landscape photographs was enhanced by means of introducing dynamic (although passive and pre-rendered) video animation. In fact, the animated landscape-stimulus allows us to address the problem of considering the experience of landscape with reasonably effective instruments. The better experience-inducing instrument of animation also allows us to expand the front of investigation, which in previous studies was limited to preference and spatial cognition.

Finding evidence of the influence of trajectory characteristics on landscape experience would assign to trajectory the crucial role of enabling the access to the visual resource of landscape discussed above. By analyzing the reactions of participants to animations it will be possible to know whether experience varies together with the trajectory of approach to landscape, and whether such relationship varies, in turn, with the type of landscape being shown.

The contributing elements to landscape experience are constituted by spatial knowledge, landscape aesthetics, the emotional impact of environments, and the sense of place by which locations are characterized. The experimental framework accounts for such wide range of intellectual and emotional facets that characterize the psychological relationship between landscape and human beings.

More specifically, in the abundance of visual data available from the landscape, the information that makes us experience an aesthetical reaction is a deeply intertwined combination of visual factors. The cognitive framework adopted in this study relates the aesthetical reaction to the spatial information about the landscape available to the observer.

The creation of trajectories over and on a landscape can be conceptualized as a filter that selects the possible ones from the impossible ones (humans cannot fly without technological aids such as airplanes), and second, those eliciting specific perceptions over others. Filtering is thus considered to be a first conceptual step in determining the abstract conceptual structure that influences the epistemological access to landscape. A filter is primarily a technological device. However, it should not be seen as a constraint to the epistemological scope of this thesis.

Chapter 2

Literature Review

This Chapter will consider in sequence the history of the concept of landscape and the theories considering landscape aesthetics (Section 2.1); the psychological approaches from ecological conceptualizations to ideas about emotion and motion (Section 2.2); behavioral geography concepts about spatial knowledge (Section 2.3); a review of visual design approaches (Section 2.4); the cartographic and visualization perspective on this research problem (Section 2.5); some considerations about sense of place (Section 2.6); and finally some material from potential fields of application of this study, and specifically cinema and photography (Section 2.7) and planetary exploration (Section 2.8).

2.1 Landscape

Landscape has been considered an elusive concept. The landscape concept overlaps in part with the concepts of region and scenery. We can approach the concept of landscape from two main directions of investigation: it can be seen as an object, that defines a particular physical domain and a natural system supporting life; but also subjectively as scenery to contemplate from a particular viewpoint (Tuan, 1979).

Lowenthal (1961) explicitly defines landscape as *"a way of seeing"*, which therefore has much to do with the viewer as with the viewed, a mediation of the external world through subjective human experience in a way that the concepts of region or area do not readily suggest, also indicating an epistemological perspective to the problem of definition, dependent on the individual who is approaching landscape.

The subjective mediation of objective reality, carried out through *"people's eyes"* (Lowenthal, 1966), means that the combination of objective and subjective takes place in the mind, or *"in the mind's eye"* (Tuan, 1979).

Granö (1929) provides an interesting historical example of how the subjective/objective differentiation of landscape can be systematized. He formulated a new discipline called *Pure Geography*, in which the region was adopted as the basis of scientific investigation. In particular he suggested to define regions in the environment on the basis of the subjective and perceptual experience of the individual, thus proposing an egocentric conceptualization of the environment. Visual, auditory and olfactory regions were referred to a perceiving observer, thus the subject's experience defined the object of study in the world.

Landscape, in Granö's view, was a region defined by a threshold of egocentric distance from the observer, and extending up to the horizon, making in practice the concept correspond to the background component of terrain of a scene (this specific definition is not supported in this thesis).

2.1.1 History

The history of the term "landscape" begins in the 16th century when the Middle Dutch word *"landskip"*, at that time used to indicate the works of Flemish painters, was translated into English (Lorzing, 2001).

The word *"landskip"* referred specifically to a painting of a prospect involving elements like hills, woods, ruins, valleys, and towns (Shepard, 1991). 16th century Flemish painters did not promote the making of a faithful depiction of the environment: rather, their paintings had an overwhelming spiritual and allegorical component, although their symbolic content was articulated in a landscape view. Only in the 17th century Dutch painters presented a more "realistic" and "documentary" attitude than their Flemish counterpart.

The Dutch *"landskip"* still resulted from a considerably creative composition of directly experienced scenery with other landscape elements (like buildings and churches). Those elements were placed in semantically "strategic" positions according to an underlying desire to express their interest for their land, and to extend wishful control on the menacing flooding waters, especially by depicting land which was not flooded (Adams, 1994).

The term "landscape", which derived linguistically from *"landskip"*, similarly refers to the definition of *"view or prospect originated from one point of view"* as given in the context of artistic painting later in the

Figure 2.1: William Turner. Fall of the Tees, Yorkshire. c.1825-1826. Watercolour on paper. Private collection, UK

18th century (Cosgrove, 1984).

In the context of 19th century English painting, William Turner was making use of the variable of viewpoint location in order to distinguish his works from those of other contemporaries, that were making portraits of picturesque scenes adopting a point of view located at ground level, which corresponded to the typical (and loathed by some) tourist experience of the landscape. For example, the painting *"Fall of the Tees, Yorkshire"* of 1827, by William Turner (see Figure 2.1), is based on a choice of viewpoint location that is placed in mid-air in front of the waterfall, instead of adopting a standard and ground level view

(Helsinger, 1994).

The contemporary interpretation of the term “landscape” took shape in the late 19th century as a portion of territory that is comprised in one view, including its constituting objects in their pictorial aspect (Harrison, 1994). This transition signified the transformation of the term from the status of identifier of a representation to the specific content matter of such representation. Later it became attached to the cultural elements comprised in the view (Cosgrove, 1984).

According to Harrison (1994), the effect of a painting is not necessarily dependent upon the location of the viewpoint or the latent landscape content that is disclosed when that viewpoint is adopted. Rather it has to be found in a *“coincidence between thought and making”* that is beyond viewing and latent content. By “effect” it was meant the ability to convey a naturalistic impression to the viewer.

2.1.2 Aesthetics of landscape

In philosophy, aesthetics are the study of the meaning and the nature of art, but the term has a different meaning when applied to the environment (see Berleant, 1992) or to media (see Zettl, 1990). The study of the aesthetics of the environment finds a theoretical justification in the original interest of aesthetics for the natural world, even if historically only a few philosophers diverted their attention from art to nature.

First, an informational interpretation of aesthetics is based on seeing the environment in its collative properties, that is, the properties that link structurally the elements of the environment together. Aesthetic response is a function of those collative properties (such as novelty and complexity) and of the explorative behavior that they consequently elicit. In particular, aesthetics interprets exploration in two ways: *specific*, such as a search in the landscape for information (i.e., for a specific view) to diminish uncertainty and satisfy arousal; or *diversive*, that is, aimed at finding a stimulus configuration that grants optimal levels of uncertainty and arousal (Hartig and Evans, 1993).

Kaplan (1987) expanded the informational theory of aesthetics suggesting that our preference for landscape depends on the kind of information processing that is necessary to perceive and relate with the environment. According to this theory, we have evolved as human beings by preferring those landscapes characterized by a particular bal-

	Understanding	**Exploration**
Immediate	Coherence	Complexity
Inferred	Legibility	Mystery

Table 2.1: The information model of environmental preference, from Kaplan (1987)

ance between order and uncertainty, that are in turn organized in four separate factors: *coherence*, *complexity*, *legibility* and *mystery* (see Table 2.1). The element that helps the understanding in the immediate time frame is the *coherence* of the environment. When the observer is instead involved with the environment, such as during exploration, it is the *complexity* of the environment that engages aesthetically the individual. In case the observer is engaged in a prolonged interaction with the environment, the understanding effort is coupled with aesthetical satisfaction if the environment is *legible*, and, in case of exploration, if it generates *mystery* (Kaplan, 1987).

The mystery factor is exemplified by a landscape picture representing a road in the foreground that turns and disappears from view, indicating that further environmental information is available as soon as the observer changes her location and moves towards the hidden part of the landscape where the road turns.

Another classical example of promised information is a view on a landscape that is partially occluded by some foreground foliage, suggesting that more satisfying environmental information is available as soon as the intervening element is removed from view by walking forward. Also, the mystery factor appears in the literature as the factor explaining the greatest variance when compared with the effect of the other three, thus indicating its dominance in explaining landscape aesthetics.

Appleton (1996) proposed the theory of *Prospect-Refuge*, based on the non-experimental analysis of landscape paintings, according to which one likes or dislikes a scenery or landscape depending on biological considerations of survival. *Prospect-Refuge* theory is more specific than habitat theory and is dependent on the imagination and experience of the observer, as well as on environmental conditions.

In particular the two situations of seeing and being seen are the fundamental building blocks of an aesthetical consideration of landscape. From an evolutionary point of view we have evolved by preferring those areas that afford prospect on the prey and at the same time refuge from a possible predator (*"to see and not to be seen"*). Landscape preference as suggested by *Prospect-Refuge* is not a conscious activity but in some ways it underscores our sensations of pleasure in the landscape.

Mitchell (1994) argues that Appleton's theory presupposes the presence of a universal and "natural" observer of landscape, leaving out other categories of observer, such as woman, gatherer, tourist, etc. However the author also suggests how the predatory and violence-based (hunting, war, surveillance) observation underlies any category of observer. This is in line with a theoretical linkage between Appleton's theory and evolutionary psychology, that defines evolutionary biases as the basis for landscape aesthetics.

In summary, the variable land surface of *Prospect-Refuge*, with places to hide and prospects controlled by topography, finds aesthetical justification by means of an evolutionary preference for survival. Topographical features, when they control the observer's viewpoint, afford specific aesthetical reactions.

Aesthetics is an important contribution to our experience of landscape. It has also been suggested that landscape aesthetics is not to be considered as an applied form of a more general aesthetics (i.e. the one studied in Philosophy), but rather the most fundamental aesthetics for human beings, mainly because humans have learned to evaluate the external world (i.e. the environment) before anything else.

2.2 Psychological approaches

2.2.1 Ecological psychology

Ecological perception Gibson (1979) proposes the concept of ecological perception, that rejects the previous "classical" view adopted in Psychology that considered the human being to be operating as a passive receptor of strictly sensorial stimuli from the environment. According to that view, those stimuli were processed and recomposed internally to make sense of the external world. Instead he suggests that the process of perception is in reality one of dynamic interaction between the human being and the environment: humans walk around the landscape, turn their heads in different directions, in a word they attune to the environment in their continuous search for information. They are active receptors, and they can improve at that by means of experience.

At base level, perception is different from sensation. Although we perceive invariants because they are correlated with sensorial stimuli, we can have perceptions without sensations. In fact, an edge of an object that disappears behind another one does not cease to exist for our perceptual system: although we don't receive direct sensorial stimuli from it anymore, we know that it is simply *hidden*.

Perception is also considered by Gibson to be strictly related to the natural motion of the observer in the environment, as in reality there is no such a thing as a static observation, since, even without moving our bodies, our eyes are always in continuous motion (Gibson, 1979).

Affordances Gibson's ecological approaches to the psychology of perception also suggest a functional interpretation of the environment that can help explain the processes underlying the human-landscape relationships considered in this study.

The concept of *affordance* was proposed by Gibson to explain the fact that humans can directly perceive the functional properties of the elements of the environment without having to completely reconstruct those from individual percepts. For example, we don't need to reconstruct a complete mental model of a chair from individual percepts in order to deduce that we can sit down on it. According to the ecological framework of mutual human-environment interaction, humans are able to function according to the affordances they perceive while interacting with the environment.

This functional interpretation offered by Gibson also indicates how perception might underlie all human-landscape psychological relationships, extending the concept of information pick-up beyond the single percept to other more complex organizing principles (Gibson, 1979).

Perspective and invariant structure A useful distinction to make is between the perspective structure and the invariant structure of the environment. The perspective structure refers to the changing appearance of the environment as an observer moves through it, and can be described in terms of *optic flow* as indicated in the next Section. For example, when we approach a chair, the actual shape of the legs of the chair change and deforms according to the continuously changing angle at which we are looking at it.

The invariant structure, on the other end, consists of the information content of the environment, articulated in terms of the so-called invariants. The invariant structure is perceivable through the continuously changing perspective structure, but it is not any particular instance of the *arrested* optic flow that we can abstract from our experience of continuous motion in the environment by *freezing* time to one instant (Gibson, 1979)

God's view Another concept that will be useful in this study is the so called *God's View* of the environment. It consists in the integration of all the possible perspective views available on a given environment, and it is not simply the "sum" of those views. For example, considering a landscape, the *God's view* will consist in the integration of views available along all possible trajectories (which is an infinite set) described in the space above the terrain.

Isovist A concept related to the visibility-based view of landscape is the *isovist* (Benedikt and Burnham, 1985). The *isovist* is an extension of the Gibsonian concept of optic array and it could serve as a foundation of studies dealing with the perception of space.

In practice, it consists in all of the information arriving to the eye by direct light rays (that is, without considering reflections), containing cues about the distance of objects and the layout of the environment. Variations in the *isovist* induce variations in the perception of the environment, in a manner that can be controlled experimentally.

The geographical concept of *viewshed*, as explained in the Section *"Visual landscape resource and design"* below, is related to *isovist*, and indicates in particular the area of terrain that is visible from one defined viewpoint. *Viewshed* is perhaps more directly applicable to landscape modeling approaches, but the *isovist* is more suitable to investigate perceptual and aesthetic response.

2.2.2 Psychology of emotion

Environmental psychology is concerned with the impact of physical stimuli on human emotions and on behavior. It is based on the existence of a metric and taxonomy for the description of the ordinary physical environment. This description is based on the two factors of sense modality and *information rate*, which are simplified by the mediating variables *pleasure*, *arousal* and *dominance*, correlated empirically with stimuli and behaviors (Mehrabian and Russel, 1974).

Information rate represents a unified measure to integrate the diverse concepts of complexity, randomness, heterogeneity, novelty, etc. Those aspects relate to information in the sense that they are based on the uncertainty that characterizes the displays. In complex situations (including video recordings) verbal measures can extract the information rate of the environment (Mehrabian and Russel, 1974).

The desire to explore a situation combines several aspects including liking, desire to seek out and not avoid a situation (Mehrabian and Russel, 1974). This idea probably transfers to the desire to explore a landscape, which will be highest when arousal is at intermediate levels and when the landscape being explored is particularly liked.

2.2.3 Psychology of motion

The investigation into the psychology of motion provides a framework to relate the experience of landscape to its fundamental psychological underpinnings. The objective is to find a theoretical basis to analyze video animations according to visual structure, as captured by human vision.

An important comparison to make is between static displays and motion. The information carried by static displays is considerably high, even without relying on motion. The study of distance perception identified gradients of textures in the optic array as determinant elements in perceiving exocentric and egocentric distances. Texture can be stochastic or regular, and aligned parallel or orthogonal to the picture plane, generating respectively linear perspective and compression. The perception of surfaces is based on the implicit structure of the optic array that allows detecting geographical slant independently of optical slant (Gillam, 1995).

Static depth cues include occlusion, relative size and density, and aerial perspective, while motion parallax characterizes the environment in motion (Cutting and Vishton, 1995). Motion has special implications for the perception of three-dimensional structure (Todd, 1995) while the framework for self-motion identifies the type and amount of motion information specified by the visual field of a moving person (Warren, 1995).

In particular the optic flow consists in the change in structure of the optic array due to the displacement of the point of observation before it is sampled by the eye. The optic flow contains information about the 3D layout of the environment and about the process of self-motion. The optic flow specifies also the effect of motion parallax, based on the different optical velocities of objects located at different distances, thus generating velocity gradients (Warren, 1995).

The invariant structure of the optic flow is important in the formation of survey knowledge, since it specifies object-to-object relations instead of the self-to-objects relations specified by the perspective structure. This idea results useful in establishing a link between visual information and spatial knowledge (Sholl, 1996).

2.3 Spatial knowledge

One aspect of this study is to assess the spatial knowledge of the environment that develops after exposure to animation. To achieve this goal it is important to discuss the nature of the process by which landscape information becomes spatial knowledge.

The spatial experience of a landscape through the medium of animation might involve the development of a mental map or schema that includes visual memories of the appearance of the surface, the location of major natural landmarks and the shape of the topography, as well as the spatial relationships between the visual elements of landscape. Sholl (1996) suggests that while much animal navigation takes place without visual information by the process of dead reckoning, instead in human beings vision is a fundamental sense modality for spatial knowledge acquisition.

The second approach considers wayfinding to be a process deriving from the perception of the environment, without requiring the construction of cognitive maps. This ecological approach states that, while moving, instead of perceiving static snapshots of the environment that are later integrated into a cognitive map, we rather perceive the continuous optic flow and the invariants of the environment as they are picked-up over time. This allows us to acquire a holistic, higher order perception that is not dependent on the original viewpoints, and which also does not require the existence of a cognitive internal representation (Heft, 1996). However, the contribution of cognitive factors is acknowledged in the sense that memory has a role in certain forms of spatial behavior that perception alone cannot explain (Heft, 1983).

Each view and each path in the environment is unique, and we can distinguish in the perspective flow an alternation of vistas (a set of unhidden surfaces seen from a vantage point) and transitions (portions of a route where an occluded view replaces the current view), respectively characterized by a low magnitude and a high magnitude of change. This defines the temporal character of navigation on which perception is based (Heft, 1996). This is important in landscape animation because it allows us to formulate the idea that spatial knowledge is a higher order perception of landscape when perceived within a temporal structure.

The ancillary effects of cognitive processes on perception might account for the influence of memory, experience and culture in spatial knowledge acquisition, storage and utilization. Cognitive maps might be considered as a representation of spatial knowledge rather than as a fundamental structure. This solution is interesting because it relies directly upon perception to explain spatial knowledge, thus presenting, together with the previous discussion on aesthetics, an occurrence of the fundamentally perceptual nature of landscape experience.

The animation used in this study can be classified as an indirect source of spatial knowledge, since it conveys spatial information in-directly through a pictorial representation, and it is contrasted with direct sources that involve apprehension of spatial knowledge directly from the environment via sensorimotor experience.

2.4 Visual landscape resources and design

The idea of visual resource stems from a particular interpretation of landscape that considers directly the outcomes (benefits, or negative influences) made visually available to us by landscape. These outcomes might depend on the characteristics of both the physical elements observed and the cognitive processes within the observer, but including also the particular dynamics of observation.

It is considered difficult to identify the visual resource of landscape. One direction of investigation is to shift the attention from the quality of the landscape to the quality of the person impacted by a scenic view. In turn, the properties of viewers, from a visual resource management standpoint, are considered products to be managed. The products include mood, mental health, physical health, and learning (Bishop and Hull, 1991). A management solution is to develop a construct of visual quality instead of relating each product to a manageable characteristic of the environment, a procedure that is impossible at the actual state of research (Bishop and Hull, 1991).

The possibility of learning about the landscape deserves special attention as an interesting form of visual resource (Bishop and Hull, 1991). This aspect can be related to the process of learning about the physical elements of landscape, which, in the context of this thesis, depends on the trajectory along which the landscape is seen. Landscape as a resource can be based, in other words, on the idea of knowing the landscape. The learning component of resource suggested by the authors attaches an economical value to the degree of epistemological access to landscape that has been reached.

Another interesting aspect involving the visual properties of landscape can be found in the area of landscape design. Here the interest shifts toward the structure of landscape and the elements that compose what we see in the landscape. Visual elements like point, line, plane and volume have been applied to the visual interpretation of landscape. The pattern of change defines several variables of interest. *Shape* (or *form* when considered in 3D) is concerned with the variation of lines and the edges of planes and volumes, and describes the irregularity of landforms. *Time* varies in terms of change in landscape attributes, but it is also involved in motion and the position of a moving observer: landscape is in fact often observed from a moving position (such as a car or an airplane). Different speeds of motion affect perception: with high speeds the eye takes only general picture and focus on distant parts of the environment.

Another variable of interest is *visual force*, which describes lines of visual forces in the landscape that suggest particular observation patterns. *Genius loci* is a design concept similar to sense of place by which landforms are key defining element when the landscape is predominantly natural. The issue of *scale* influences our feeling of enclosure in a landscape that depends on the height of the enclosing element and its distance from us. Perception of *scale* changes from distant view to middle ground and foreground where texture is well visible, and the height of observers affects the perception of *scale*. In fact, down in the valley the landscape is characterized by short distances, limited views and strong sense of enclosure, while from a summit the valley is a part of landscape at a wider scale (Bell, 1993).

Shape is of particular interest among the visual variable for the way it defines landscape profile and landscape form. The manipulation of height has important consequences on the feeling of enclosure and the scale perception.

Visibility is a central concept in the visual studies of landscape. The concept of *viewshed* can be related to the analogous psychological concept of *isovist*. Despite the fact the two were originated in different disciplines, they both refer to an objectification of spatial intervisibility, respectively in a terrain context and in an architectural context. It might be possible to link visibility to landscape aesthetics, but the method will not be developed in this thesis. On this front, the work of Llobera (2003) leading to the concepts of visual exposure and *visualscapes* allows us to structure spatio-analytically the idea of perceptually-filtered visibility. The idea hinges upon an observing entity that necessarily makes explicit the spatial structure of landscape. Llobera (2003) also offers technical solutions to represent and visualize those total properties of landscape picked up by human perception and previously left implicit in obsolete 2D GIS models.

2.5 Cartographic visualization

The display of three-dimensional cartographic objects, when the variable is a single Z surface, is called surface exploration. When immediate control on the visualization is provided, the exploration becomes dynamic. While there has been considerable interest in attempting to discover an optimal viewpoint over a static terrain, a dynamic display offers instead a moving viewpoint: the cartographer is not limited by a fixed view, but she has an almost infinite range of options for representing a terrain surface. The advantage is evident when the complexity of the surface is so high that no single viewpoint can be sufficient for understanding the surface. All the dynamic changes implicit to this approach are to be considered part of cartographic design (Moellering, 1980).

In the literature there are examples of the use of scale and orientation/viewing parameters variables to study the effects of spatial knowledge acquisition from maps (Taylor, 1984), especially in their cognitive component (Eley, 1992). They suggested that these variables have a strong influence on the cognitive processes of map reading.

Landscape animation can be considered as a form of landscape visualization in motion, and therefore as an extension of three-dimensional cartographic representation. Kraak (1988) investigates whether the three-dimensional map can be considered within the same theoretical framework as the ordinary bi-dimensional map. 3D maps avoid the problem of interpretation of more abstract devices like contour lines and offer depth cues to the observer to interpret correctly the image. A differentiation is made between a map that can be understood at a glance without demanding great cognitive resources, and a map that requires more careful and non-instantaneous interpretation. In practical terms a 3D perspective map with realistic textures drawn on top might be more cognitively demanding than a 3D perspective map with just the fundamental depth cues. When considering the addition of the fourth dimension of time, Kraak's framework would probably predict a cognitive overload. Instead, real-time cartographic animations can be "consumed" without particular overloads (Kraak, 1990)

In fact, at this point it is worthwhile asking if those animated visualizations need to be considered as maps requiring interpretation or rather as the synthetic counterpart of real world video images, in a cinematic framework. Supposedly this depends on the kind of interpretation required of the participant. Spatial knowledge acquisition requires a sophisticated visual analysis from the participant (including distances, locations, slope, etc.), while aesthetic evaluation probably requires a more holistic emotional interpretation, which has little to do with the interpretation of a map as it is normally conceived.

Geovisualization as an emerging discipline has the “time invariant” objective to provide a framework to extend the scope of research to other disciplines and to other non-traditional collaborators including the entertainment industry (UCGIS, 2000). In this light, the analogies between certain types of animation and film can be seen as examples of situations in which geovisualization might be related to other media other than the cartographic-based representations.

Geovisualization literature uses the important concept of exploration to represent the earliest phase of the process of visualization, namely the one responsible for obtaining a sense of the existing patterns in a dataset before proceeding to the later stages of confirmation, synthesis and presentation (MacEachren, 1992). It is a process of revealing the unknowns of a dataset, and thus it can be considered part of the process of information discovery. In this light the *"seeing the unseen"* of visualization can be considered as a way to gain a new perspective on data and developing new concepts based on the discovery of new information.

In recent years animation has received increasing attention in geovisualization. The three dynamic variables of animation proposed by DiBiase et al. (1992), namely *duration*, *rate of change* and *order*, were devised mainly for abstract representations but they can work with fly-by animations such as those used in this study.

The use of animation for the exploration of three-dimensional terrain surfaces, as exemplified by the Jet Propulsion Laboratory (JPL) planetary fly-bys, has military and geological applications, but also more human-related ones, such as the representation of human movement and interaction. Campbell and Egbert (1990) also reported that in the design of terrain animations it is necessary to control the effect of the overwhelming novelty of the medium. For example the animation *"L.A.: The Movie"* by JPL, showing a fly-by on the city of Los Angeles and on its most important features and landmarks, arguably offers only a limited chance to orient oneself in the represented environment due to the high speed of motion and the rapid turns of the trajectory of the camera.

Cartography does not consider landscape only as a terrain object. Burt (1995) presents the issue of considering maps as devices for developing a sense of place (see also Section *"Sense of place"*). The emotional involvement that we can experience with a carefully designed map works as a stimulus to gain new knowledge. When considering a work of art, we show empathy caused by feelings related to what we find. In the same way a map, characterized by clear presentation of information and a particular "mood" due to tone and compositional arrangement, might provide a new experience that links memories and concepts related to place. A combination of map, graphic image and photograph in a multimedia type virtual map may be used in enhancing the sense of place (see below).

There are several examples in the literature concerning 3D visualizations of landscape, considering technical aspects of actual methods of computer graphics (Graf et al., 1994) and remote sensing (Graf, 1995), and an overview of techniques (McLaren and Kennie, 1989) and applications (Berry et al., 1988). Other specific studies on environmental visualizations can be found in the Landscape Planning literature.

The representation of terrain in three-dimensional cartographic maps introduces the problem of finding a suitable multiplying factor, called *vertical exaggeration*, for the z value (elevation) of the terrain on the map. In fact it was suggested that 3D maps *look* more realistic when the vertical exaggeration is chosen according to a measure of relative relief determined by the contour interval. This aspect was investigated experimentally in Jenks and Caspall (1967). In one experiment, pairs of 2D maps with the corresponding 3D topographic maps were presented to the participants together with a scale from which the degree of over- or under-exaggeration had to be evaluated. Indicatively, the greater the relief, the greater the maps had to be vertically exaggerated in order to look realistic.

The underlying assumption of the latter study is that cartographic realism is not a property of the geometrical characteristics of the map alone, but is a function of what the viewer expects to find in the map itself. The psychological process used by the viewer (or by the map maker) in evaluating the realism of a 3D map is suggested to have an aesthetical component, even if that is not investigated further.

However, it might be argued that it is not convincing to determine whether a map is realistic or not by verifying if the condition of *"it pleases the eye"* is satisfied. In fact, the reliance on aesthetics to evaluate the soundness of the spatial structure of a 3D map, even if compared to a 2D map, might be related to the ideas on aesthetics previously illustrated. Human aesthetics simply do not respond to the level of realism of a spatial arrangement, but rather to those conditions that appear to guarantee adequate chances of survival, albeit restructured to be applied to a display that does not look like the hunter's savannah. The differences in aesthetics between the non- vertically-exaggerated map and the vertically-exaggerated map have nothing to do with realism, because anything convenient to survival would *"please the eye"*.

In general we might suggest that aesthetics (i.e., strictly what we like and what we dislike) constitutes a source of confounds as a measure of realism. For example, vertical exaggeration has been extensively used in Art to produce aesthetically pleasing landscapes, dramatically showing greatly enhanced cliffs and extreme formations in portraits of areas that in reality were more scaled-down.

In the context of this study, the vertical exaggeration applied to all landscapes used as materials in the experiment is always equal to 1 (i.e., no vertical exaggeration). In fact, it is argued that the realism of a first-person perspective view of a geometrically realistic landscape visualization is analogous to its real counterpart, that is, the three-dimensional projection on the picture plane of the unmodified topographic dataset, where all the geometric properties of the terrain are preserved.

It must be stressed that the only source of what here is called realism in the geovisualizations used in this study is geometrical, provided by the GIS software, maintaining proportions, spatial structure, and soundness of methods of projection in a coherent framework that covers all landscape design instances used in the study. In turn, this relies on the terrain dataset used, which was obtained from physical reality.

2.6 Sense of place

Sense of place is a vague umbrella concept incorporating many different aspects related to place. It combines the ideas of location, landscape and personal involvement in place, includes concepts of identity and attachment to an area and, overall, it offers a stronger unity than the region concept. Phenomenologists do not define the term and leave the meaning to the user, while operational definitions were tried for empirical studies (Shamai, 1991).

Muir (1999) addresses the issue of landscape and place in the broader context of landscape studies. Sense of place derives from two main factors: 1) the intrinsic personality of places which are visually striking and produce powerful images and 2) the emotional attachment to localities when considered as home settings. Landscape makes a substantial contribution to the sense of a place, and determines many qualities of it, including the character of the scenery.

Tuan (1975) proposes a scale of classification: at one end there are places that are remote from sensory experience considered as points in a spatial system; on the other end there are places eliciting visceral feelings and rooted in a locality.

Sense of place is expressed at different scales, from home to nation, constituting multiple centers of meaning. Sense of place has also been reported to be possibly varying with differences in age, upbringing, class and gender. The sense of place for an area might vary with the view characteristics, such as the perspective of a traveller from the top of a hill versus a farmer in the valley below (Muir, 1999), although there are few, if any, experimental studies investigating this aspect of topographically-dependent sense of place. However, the height of a place as a factor in the perception of the environment was considered from a cultural point of view: for example, the experience of seeing a city from the top of an observation tower, after being used to a ground perspective, is suggested to change the relationship with the city itself. Other examples are the artistic panoramas in painting and photography (Dubbini, 1994).

Tuan (1975) considers that, in terms of experience and time, sense of place is rarely acquired in passing, and in order to know a place well a long residence and deep involvement is required. Visual qualities, however, are appreciated in a short visit.

An empirical self-report measurement scale of sense of place was developed by Shamai (1991), and it is based on a scale from lower (alienation, homelessness, not belonging) to higher (identity) sense of place, subdivided in steps of knowledge, feeling of belonging, attachment, identification, involvement and, finally, sacrifice. Smith and Brown (1996) elaborate a sense of place concept in the context of education amongst schoolchildren, where place is listed among the core elements of Geography. Their version of the concept does not include an aesthetic component and it seems entirely based on a notion of environmental awareness, a form of deeper knowledge of the surroundings and the ecologic system behind our daily lives. In both examples the role of knowledge as the base of sense of place is stressed.

2.7 Approaches in Cinema and Photography

Sitney (1993) reports several examples of cinematic techniques. Early in the history of cinema the panoramic sweep (or pan shot) emerged to convey to the viewer the impression of a boundless viewpoint. The long shot, hinging on the subjective view of deep space, is distant in relation to the center of human activity and has an establishing function, locating an individual in a wider landscape, emphasizing human dominance and diminishing human scale. The long shot has a cinematic meaning in the context of other shots and alternate perspectives, whereby it serves as an establishing shot for other subordinated ones. Zooming is another element of Cinema and consists in a virtual movement of the camera to traverse landscapes and indicate possible trajectories for exploration.

What can be gained from considering Cinema in this study is not only the use of the specific techniques, but a level of complexity of dealing with moving elements for communicating content that is unparalleled in the context of dynamic visualization. The concept of spatial articulation (Johnson, 1974) is important in Cinema, and it is based on the notion that spatial relations expressed on the screen by a combination of camera movement and implied filmic space are able to produce content and to elicit emotions. Spatial articulation comprises the main factors: the first is proximity of the camera to the target, generating a set of contrasting reactions in viewers such as removal-involvement and conceal-reveal. The second factor is the angle of vision, with the subtle aspect of relative closure, creating patterns able to communicate different messages such as rationality or spontaneity according to their intrinsic movement. The two factors are influenced by the timelines of motion that communicate additional messages, especially using the device of montage, i.e. composition and editing of scenes to confer acceleration and eliciting particular experiences in the viewer.

A parallel can be made between landscape animation and these general cinematic elements, because they are particularly significant in suggesting a direct implementation in the context of this study. For example, proximity generates involvement similar to a close-up view of a landscape, which can then elicit sense of place in the viewer (the opposite is also true, with aerial views suggesting a sense abstraction from a place). At this point it is useful to go beyond analogies and consider the way in which Cinema combines all the different elements in communicating a precise message. Since Lumiere the very location of the camera or the lens used were the devices for communicating a message, which became more complex as more elements were added to the picture (Huss and Silverstein, 1968).

2.8 Planetary exploration

By considering research in planetary exploration we are able to gain an insight into the concepts of presence, place and exploration. McGreevy (1993) reports that the first Lunar Orbiter images of the

Moon (years 1966-1968) offered the first oblique perspective views of the Moon, making it seem *"more of a place"*. Perspective views add the component of place to an otherwise impersonal notion of terrain, and therefore a sense of presence is possible in such representations. A similar sense of presence is produced by the lunar photo panoramas, whereby mosaics of photographs were displayed on spherical screen and gave an impression of presence to the observer located in the center.

In the terrain exploration tradition, McGreevy (1993) adopts the view according to which the environment must be experienced concretely and directly through personal experience in order to appreciate the affordances of an environment. Such personal experience can be surrogated by virtual reality or by other forms of representation in varying degrees of efficacy. By exploring a digital representation of a planetary terrain it is possible to gain a specific understanding of the place represented, enabling an expansion of the capability of exploration of the scientist. The main difference between orbital and surface views is that satellite pictures are perceived as a 2D texture, not a habitat or environment, while surface views are the kind of views that humans have evolved to perceive. As far as motion is concerned, it might be argued that without "moving around" there is a diminished understanding of the spatial characteristics of the place (McGreevy, 1993).

The JPL/DIAL (Jet Propulsion Laboratory/Digital Image Animation Laboratory) in Pasadena, California, produced several fly-by animations of the surface of several planets (specifically, Earth, Venus, Mars and Miranda, a satellite of Uranus) (DiBiase et al., 1992). McGreevy (1993) considers that all viewers reported a greater visual and spatial appreciation of the planetary environments after seeing the videos, and later stressed that the nature of this appreciation is to be found in the concept of *presence* (personal communication). In these respects, McGreevy (1994) further investigates what is the nature of the understanding of geologic environments from the point of view of a field geologist. The main characteristics of such field experience are the continuity of presence, that is, the possibility of traversing the field and observing an object without any discontinuity in the personal action space. In other words, presence is related to continuous natural locomotion and seamless shift of attention from the environment to the individual sample collected in the field.

Chapter 3

Conceptual Framework

3.1 Introduction

The main focus of this Section is to provide sound theoretical arguments supporting the experimental design and in particular the choice of independent variables. The fundamental factors distinguishing the two experimental conditions from each other are reviewed and evaluated on the basis of experimental evidence and theoretical considerations. In fact, a differentiation between camera trajectories is proposed based on the variable of camera altitude, which in combination with camera elevation angle can be used to generate two qualitatively different viewing conditions (i.e. ground view and layout view). The objective of this study is to evaluate whether the two viewing conditions elicit different responses. A discussion will be articulated by comparing the specific ability of the two trajectories to cause different types of environmental information to be displayed.

3.2 Theoretical aspects of landscape

Historically, landscape has been seen as the result of an act of seeing, and of framing the environment in a painting realized from a specific point of view and characterized by a particular viewing angle, making an area of land visually accessible to a viewer. In the history of landscape painting this selection operated not only on concrete landscape elements, but also on compositions of materials taken from spiritual and conceptual spaces (see 16th century Flemish painting in the Literature Review).

It is convenient to retain the definition of landscape originated in artistic painting. Instead of focusing on the characteristics of the constituent elements of landscape, the approach is instead to consider the preliminary step prior to any human-landscape relationship, that is, the idea of exposure to landscape.

Landscape exposure Landscape exposure can be seen as the spatio-temporal description of the information-seeking process illustrated by Gibson by means of which humans learn about the environment by walking on the ground, turning their heads towards interesting areas, and moving their eyes around. The adaptive exploration of the environment is suggested as similarly important as the intake of sensorial correlates for information pick-up.

The adaptive perception of a human being is limited to the height of the eyes when walking, to a turning angle of the head of maximum half a circle, and to a viewing range allowed by the resolution of the eyes. A pilot of a helicopter, instead, has a different set of intrinsic limitations, such as the field of view allowed to her by the cockpit, limiting in turn the potential range of visibility initially offered by the eyes.

The strategy suggested in this study is to force the participant into very specific conditions of limited landscape exposure, such as a high altitude and uniform flight, reproduced in a fixed resolution animation screen. Since the perceptual information pick-up depends on those constraining aspects related to adaptation, we conclude that particular constraints on movement might generate different patterns of information pick-up.

For example, if we fix in the real world the orientation of the head of a person in a central position using a special device, so that she cannot turn it around freely, we might impair the efficiency of information pick-up for that person in most environments. In a sense, it is like ruling out all possible choices of head orientations except for one. It might be argued, on one hand, that any constraints on adaptive perception can change how well information is picked-up. Similarly, on the other hand, imposing changes on any variable on which adaptive perception is articulated, affects the process of information pick-up.

It would make sense, in other words, to investigate whether a high altitude fly-by is perceived differently than a low altitude fly-by, which is the main tenet of this study. In fact, it is not only a matter of predicting how the visual properties of the visible landscape, and in turn the participants' perceptions of them, change between the two trajectories. The issue might be related to the more fundamental fact that a restricted visual access, imposed by defining an observer's trajectory, might be a constraint on adaptive perception, or even something that extends the normal possibilities of adaptive perception (i.e. flying above the landscape allows the observer to gain a layout view which is not limited in breadth as a ground level view).

The ecological and Gibsonian idea of considering of great importance the role of adaptive behavior in perception, can be seen as supporting the fundamental idea of this study, that is, the dependency of the outcomes of the process of information pick-up on the spatio-temporal dynamics of body, head and eye movement, and thus on the characteristics of those dynamics when constrained and "packaged" in defined observer's trajectories.

Filtering approach to landscape The framework proposed in this thesis indicates that the *God's View* of a given environment is the conceptual starting point for any further analysis of the visual landscape. The totality of views afforded by a given terrain, and articulated in infinite viewpoint locations and viewing parameters, can be seen as the complete representation of all the possible ways we can look at a given terrain.

When we look at that terrain from a single viewpoint, defining it from the infinite set of viewpoints available on or above that terrain, the *God's View*, originally defining a viewpoint *class* of entities, is reduced to a single *instance* of viewpoint, from which a particular view of the terrain can be obtained.

This process of defining a single viewpoint from the totality of viewpoints of a *God's View* can be considered as a kind of selection. The concept of filter, developed in engineering and used also in other disciplines such as ecology and psychology, might be useful in describing the mechanism that, in its more abstract sense, maps the entire set of source viewpoints onto one single final viewpoint.

The important idea is that the immediate result of the *God's View*-to-single-viewpoint mapping process is the fact that the terrain, from being implicit and object-like, becomes viewable in a general sense. The terrain becomes accessible through the first-person, egocentric framework of the observer. At the same time, besides becoming "viewable", it also instantiates a particular view, or optic array, characterized by precise viewing frames. In other words, with the act of defining a view, a specific perspective structure is also explicitly defined, through which the invariant structure of terrain can be perceived.

From a philosophical point of view, a filtering process applied on the *God's View* determines the perceptual accessibility of landscape, which defines the first step to come in touch with the visual resource. In general, in order to perceive landscape, we need to be immersed in its perspective structure.

In this thesis it is proposed that the term "landscape" signifies the instance of a view on the terrain generated by the filtering process. This definition is in line with the historic definition of landscape as *"a view on the environment"*.

3.3 Human-landscape psychological relationships

Within the landscape framework, the nature of the human-landscape relationship is measured as the psychological response to the particular conditions of viewing determined by a specific instance of landscape after filtering.

Human psychological response is based on the ecological nature of the human-landscape relationship. Humans are seen in interaction with the landscape, developing relationships based on aesthetical evaluation, spatial knowledge acquisition and development of sense of place. The fundamental aspect is aesthetical evaluation, that is a synthetic element, while spatial knowledge is integrated with the other two by providing a knowledge base for evaluation and feeling. Sense of place is considered here in its aesthetical and evaluative component.

Those three elements are based on heterogeneous concepts, thus their investigation in combination might present methodological problems, such as considering affect and cognition at the same time, that are difficult to tackle in a single study. However, the approach used in this study makes the research problem conceptually more focused and manageable, while preserving the diversity of angles from which landscape is investigated.

This research approach emphasizes the perceptual and cognitive dimensions of the human-landscape relationships. Aesthetic preference is considered to be the result of unconscious cognitive information processing (see the relationship of this idea with landscape preference in

Kaplan (1987), despite the interesting hypothesis that affect is independent of cognition (Zajonc, 1980)). The two views reported here agree on the fact that aesthetics is probably not solely the result of conscious information processing of environmental information. Spatial knowledge consists of the result of encoding of environmental information in knowledge structures, and it is considered a result of cognitive processing, though the literature presents discordant views (see the Literature Review and Heft (1996)). Sense of place, as explained below, is considered here only in its cognitive component of place identity and character, closely related to aesthetics and to an evaluative relationship with landscape. Non-cognitive interpretations of both aesthetics and sense of place are not directly considered. The reason for emphasizing cognition comes from the idea that a fundamental layer of cognitive information processing might underlie spatial knowledge, aesthetics and sense of place. Therefore it is interesting to evaluate the proposed aspects of visualization primarily considering this layer.

Besides the cognitive emphasis, this study is also centered on aesthetics, which consists in the evaluative component of the human-landscape relationship. Spatial knowledge is considered here only as an auxiliary source of information about the human-landscape psychological relationships, since the study is not designed to specifically investigate the process of spatial knowledge acquisition. It is nonetheless argued that having an insight into people's knowledge of the spatial structure of landscape might inform us on the extent and kind of information base used for their aesthetical evaluation of landscape. Sense of place is instead considered in its cognitive and evaluative component, rather than in its specifically affect-based component of place attachment. Central in this context is the idea of landscape character (see below) and in particular the idea of distinctiveness and uniqueness of the information base contained in a landscape. This aspect of sense of place extends the scope of the concept of aesthetics while introducing more holistic and identity-based evaluations. In summary, emphasizing aesthetics in this study is justified on the grounds of the exceptional characteristics of the evaluative human-landscape relationship. This relationship is based on the fact that aesthetics stems from the cognitive processing of environmental information (thus sharing a common root with spatial knowledge) and also on more holistic judgments that tend to be captured more by sense of place, although they are fundamentally aesthetical and evaluative in nature. In other words, by considering aesthetics as a central aspect of this thesis we can have also a convenient perspective on the related cognitive dimensions of spatial knowledge and sense of place.

3.3.1 Focusing on aesthetics

Aesthetical experiences are, in part, the outcome of an innate human ability of relating with the environment, which depends on evolutionary considerations of adaptation. Other contributing factors are the human cognition of stimuli from the environment, and culture.

In Gibsonian terms, the *Prospect-Refuge* theory is a description of landscape in terms of prospect and refuge affordances, that is, the functional values of landscape (Hartig and Evans, 1993). Gibson (1979) in fact suggested that the affordances of the environment are perceived by an observer by means of a process of direct perception that even preceded the process of classification. Although Gibson never specifically referred to aesthetics, he hinted at the concept of *higher order invariants* that arguably stem from the first-order perception of the environment. This suggests how aesthetics could in principle be conceptualized as a kind of higher order invariant making use of environmental information such as the affordances of the environment.

The idea of landscape aesthetics hinges upon an evaluative relationship with landscape that refers to the fundamental and very complex (although experientially simple) process of liking or disliking a scene. However it also includes a range of appreciative relations with the environment, such as for example interest and curiosity stemming from the visual properties of landscape. The informational interpretation of landscape aesthetics proposed by Kaplan (1987) and articulated in the four informational factors of landscape preference lies at the foundations of this research approach. According to this line of thought, landscape aesthetics are a process of environmental evaluation that is based on the unconscious cognitive judgment of the information content of a landscape. Of particular interest to this thesis is the informational *mystery* factor that specifically refers to the amount of promised information contained in a landscape view. In other words, promised information in a landscape originates from actual environmental information that indicates the availability of further information after a slight change in the vantage point.

This research aims at extending the concept of mystery suggested in the literature by considering the promised information effect generated by the occlusion of topographic forms. For example, a form of topographic mystery might be the effect of a foreground hill that, by means of occluding the view on the mountain beyond, actually generates an attractive view based on the promised information implicitly made available about the mountain. This form of topographic mystery is coherent with defining mystery as a condition in which some environmental information is promised by means of actual information cues in the landscape: for example, in topographic terms, a cue might be the highest tip of a mountain visible beyond the foreground landscape.

In summary the idea is to use not only preference as a measure of aesthetics, but also other self-report variables that are built around the information factors of landscape aesthetics and that capture aesthetical perception from multiple perspectives (for instance promised information as desire for further exposure to landscape animation). As explained in Chapter 5, the experimental design consists of a measurement of landscape preference (in line with the literature) and of lower-level variables (as an extension of the research strategy) in particular conditions of actual and promised information such as those offered by specific landforms.

3.3.2 Spatial knowledge

The interest in spatial knowledge in this study is mainly related to the need of establishing a relationship between landscape information and aesthetical perception. In fact, investigating how spatial knowledge is acquired after exposure to a landscape animation is important to determine the extent of the information base used by the viewer to carry out her aesthetical evaluations. In other words, as the viewer perceives the environment she develops an information base that is unconsciously processed during aesthetical perception. A way to assess the extent of that perceptual information base is to verify how it helped develop spatial knowledge. From this point of view, investigating the extent of spatial knowledge by means of analyzing its externalizations is like giving a different look at the landscape information that contributes to the viewer's cognitions and feelings. For example, knowing the level of detail of the viewer's memories of the spatial properties of landscape can be indicative of the things she noticed and that might have affected her aesthetical evaluations.

Another component of spatial knowledge is related to the spatial awareness of the characteristics of the viewer's trajectory. Being able to remember the type of trajectory in relation to the ground is an ability that can be related to the preference for the mode of landscape exploration used in an animation. In flight simulation there is interest in modeling the way the pilot perceives the motion of the plane (Rolfe and Staples, 1986). While emphasizing there the importance of safer and more efficient flight, in our case it is interesting to study the perception of the characteristics of a trajectory as a factor that completes the experience of landscape in more general terms of self-motion awareness.

The methods used in this study to investigate spatial knowledge are based on self-report sketch maps of the plan and profile view of the landscape being viewed, and the plan and profile projection of the trajectory along which the exploration occurs. The sketch maps of the landscape contain the topographical structure of the terrain, including major topographic landmarks and landforms (see Chapter 5 below). While most spatial knowledge sketch-maps used in the literature refer to the built environment, drawing a sketch map of the natural environment is a less common task, especially when referred to a landscape lacking traditional navigation features, such as roads and nodes. However the pilot study has shown that participants are able to encode a good amount of information about the landscape in their maps.

3.3.3 Sense of place

Sense of place captures the feelings of belonging to landscape, the cultural and emotive attachment to landscape and the special emotional bonds that develop between observer and landscape due to the influence of memories of past experiences. Ideally, sense of place would extend the range of human-landscape relationships since not only could landscape be memorized (spatial knowledge) but also evaluated (aesthetics) and become the object of attachment (sense of place).

The concept of sense of place has specific implications with respect to time and memory. According to the cultural tradition in Geography, sense of place is rarely acquired in passing and requires a long residence and deep involvement. From a temporal point of view it seems unlike the quick evaluative aesthetical relationship with landscape, which instead operates in much shorter (although not instantaneous) time frames.

However, it might be argued that while a cognitive map of the environment starts to be built at a first exposure, in absolute temporal terms it takes more time to develop memories (in affective sense) and feelings of attachment to place. The current experiment design, based on very short exposures to landscape (mostly 30-second sequences), does not allow us to examine the affective attachment dimension of sense of place, as the latter would probably not develop in such a short period of time. In other words, sense of place cannot be included in full in the same experimental design together with aesthetics and spatial knowledge.

The idea of landscape *character* is not only related to an appreciative (aesthetical) relationship to landscape, but also to an early form of attachment, better represented by sense of place. The questionnaire developed for the experimental design focuses on capturing the early forms of sense of place that do not require a long exposure to landscape, but are rather attached to the idea of character and uniqueness, which almost fall into the aesthetical categories of human-landscape relationships.

3.4 Research strategy

The general strategy is to compare the psychological response of participants to two instances of viewing trajectories on three different landscapes, to see if the different filtering process of the two results in different responses, and how those responses are patterned. The specific strategy is to define qualitatively different trajectories, with a specific framing and camera attitude, but still in part related in terms of length on the ground covered and velocity. In the Sections below the criteria of trajectory and landscape design will be illustrated in light of the research strategy.

3.4.1 Trajectories

The aesthetical mystery factor (see Literature Review) indicates the importance of the visual structure of landscape, related in particular to the characteristics of actual and promised information. The visual structure depends in part on the appearance and arrangement of features in the landscape; also, it depends on the way the visual elements are presented in a view and are available to the viewer's perception.

Those two factors consist respectively in absolute and subjective structure, which are in reciprocal interaction when the landscape is explored. We can say that, for example, the mystery effect of the mountain partially hidden by the hill is not only a matter of absolute hill-mountain configuration, but also a matter of observer's location.

In the exploration of landscape there are certain trajectories that have the potential to trigger particular responses due to specific configurations of actual and promised information as suggested for example by the mystery factor. The essence of this experimental study is to compare very similar but still qualitatively different trajectories. In general the research question is to verify whether a slight variation in the viewing dynamics is able to influence significantly the perception of landscape.

It is not trivial to choose the proper level of difference between trajectories in order for them to still be comparable (i.e. able to show reasonably overlapping landscapes) but not so similar as to provoke inadequate perceptual differences. Also, designing qualitatively different trajectories means that we have to select examples of trajectories that have a particular meaning in the exploration of landscape: that is, we need to discriminate particular aspects of the landscape space that instill quality in otherwise infinite and randomly generated trajectories. Quality, in this study, comes from the characteristics of the terrain, and, in particular, from topographic variation, but in principle can be originated from any existing landscape element (i.e., vegetation distribution). However, topography is here the main aspect to be considered.

More specifically, by the term trajectory here it is meant a complex combination of all the factors characterizing the viewing experience of landscape. It includes the location of the camera as it changes in time, the location of the camera target as it changes in time, and the angle of view. The three variables can also be summarized in an egocentric framework by means of variables such as 3D location, *pitch*, *yaw* and *roll*, but the former set of variables was used because it follows closely the aspects of landscape implementation.

The variable of camera altitude is the primary differentiating factor between trajectories. From a perceptual point of view, altitude influences the viewing perspective of the landscape, since the sizes of the textures change according to the distance from the ground, and objects tend to be seen vertically from above, thus exposing horizontal instead of vertical surfaces (for example, the crown of a tree versus a tree trunk). Moreover, the visual elements in a ground view appear larger than in a layout view, and in the latter case there is a larger portion of landscape being displayed at a given time.

There is converging evidence that camera altitude is an important influencing factor in our experience of landscape. As seen in the Literature Review, the variable of viewpoint height in maps was found influential for the cognition of the represented terrain surface as a whole. Moreover, panoramas from high observation points always confirmed how the height at which the observer is located dramatically influence the perception of, and the experience in the environment.

However, camera altitude is not intended as an absolute variable (for instance 100 versus 200 meters of altitude), because it would not be a very meaningful measure given a varying topography. In particular the absolute altitude of the camera is combined with the relationship of the trajectory of the camera with the ground surface. A trajectory that is very close to the ground, resembling a low altitude, terrain-following flight (such as one of a helicopter), is very distinguishable from a trajectory that is high and uniform (such as the one of a small plane). The two are certainly more qualitatively different from each other than two uniform trajectories at two different absolute altitudes. In other words, the variable of camera altitude is used in a more complex and qualitative way than its quantitative meaning of "meters above the ground", as it combines a component of absolute altitude, a specification of a relationship with the ground surface. The lack of a "pure" quantitative variable is compensated by the gain in qualitative differences that otherwise would not be captured by quantity alone. In practical terms, the altitude of the camera in the low altitude condition will be set to a constant value above the ground. The actual altitude will be set to take into account the need for a reasonable altitude for a "safe flight" avoiding collisions with the ground, and enough proximity to the ground to fulfill the design requirements.

In the high altitude flight the altitude is less easily determined. Each landscape stimulus (see Methods) presents a different set of topographic characteristics, and the common "cruising" altitude, although independent of the terrain, will be determined on the basis of a safe flight over the highest landform of the set (major landform case, see

Methods). In the plain, valley and minor landform cases the camera will have exactly the same altitude as the major landform case, to ensure consistency across stimuli.

Another source of dissimilarity between trajectories is the elevation angle, or pitch, of the camera, that is, the angle between the horizontal and the direction of viewing. The elevation angle of the low altitude camera trajectory is approximately horizontal and does not change with the variations of camera motion, that is, when the observer moves upwards the camera is still horizontal. This behavior resembles a helicopter maintaining its attitude during flight and results in a visually more coherent trajectory because the viewing parameters are not dependent on vertical motion. The elevation angle of the high altitude trajectory discussed above would be set in such a way as to convey a more pronounced layout view of the landscape, which would contrast with the ground level view of the first trajectory. In general terms the elevation angle of a camera influences the apparent depth, relief, slope and "blocking" (i.e. degree of occlusion) of the landscape, and therefore might help create different viewing conditions which are qualitatively different. Thus, the camera of the high altitude trajectory will point downwards, with an elevation angle in between the horizontal and the vertical down to the ground. A camera looking vertically down would show very little of the distant landscape beyond the foreground terrain, thus excessively unbalancing the difference between trajectories. On the other hand the same camera would introduce the interesting comparison between a ground level perspective and a layout map view. To counterbalance advantages and disadvantages an intermediate solution was adopted. The camera was set in such a way that it was able to see part of the distant landscape but also offer the viewer a layout view. The optimal elevation angle to look at a static landscape in a block diagram was found to lie between 30 and 40 degrees (Sieber, 1996). Within the 10 degrees allowance, the value of 30 degrees is preferable since part of the sky would still be present in the picture, making the layout view still comparable with the ground view. On the other hand the amount of sky present in the animation is not controlled for in the current design. The fact that the ground view has more sky in the picture, and that therefore might tend to be preferred more for that characteristic alone, is considered a distinguishing feature of that viewing condition. Instead of controlling for the amount of sky it is preferred to maintain meaningful qualitative differences across conditions.

Therefore we conclude that the comparison will be made between a trajectory with elevation angle equal to zero (ground view) and a trajectory with elevation angle equal to minus 30 degrees (aerial layout view), on the basis of the qualitative difference between ground perspective and optimal layout perspective, a difference that indicates interestingly different modes of landscape exploration.

The previous discussion on camera altitude and viewing parameters referred to the variables accounting for differences in trajectory. Now, the aspects that are equal across conditions are considered in detail.

First, the velocity of the camera and the length of the trajectory segment being flown need to be identical. Unfortunately, the two requirements cannot be satisfied at the same time. In fact, if each trajectory covered exactly the same segment on the ground, then the horizontal velocity of the cameras in the two conditions would be identical. However, in some hilly landscapes the actual velocity would be necessarily different because the low altitude trajectory has a vertical component, required to climb up or down hilly terrain, that makes longer the trajectory distance actually flown. The absolute amount of variation of these factors varies from none in the *plain* landscape stimulus where there is no vertical component of motion, to a maximum of about 30% increase in the *Ynez Peak* (climbing landform) landscape stimulus, where the camera climbs up the landform for half of the length of the animation at an angle of 30-40 degrees. The variation is not that great to change the self-report measures substantially.

The duration in seconds of the animation is equal in all conditions and for all stimuli. The animations are designed to expose the viewer to very specific content (climbing a hill, flying over a plain) that is not the same thing as offering a general exposure to multiple aspects of landscape in the same sequence. It was evaluated that 30 seconds for each landscape was sufficient to have the required exposure to the stimuli. A considerably greater duration was not really manageable for the computational constraints on the generation of animations.

Amongst the other factors accounting for similarity across the two conditions, the viewing angle (field of view) is a variable that influences the perception of the scene in terms of the amount of landscape contained in a view, and the relative size of the textures. It is also related to photographic and cinematographic aspects such as the use of zoom for enhancing distant detail. It is proposed here that the viewing angle should not be manipulated in this design because of the complexity of the variable and its unpredictable effects on the overall landscape experience.

Another element of trajectory is the horizontal viewing direction of the camera. This measure, called yaw, represents the direction the camera is facing during forward motion. This is another variable that is kept constant, and specifically, the camera always points towards the direction of motion.

In summary the two trajectories being considered here are a low altitude trajectory of a camera flying very close to, and following, the ground, looking ahead and horizontally ("Low Altitude-Terrain Following" or LA-TF), and a high altitude trajectory of a camera flying horizontally, looking ahead, and down at an angle of 30 degrees ("High Altitude-Uniform" or HA-U).

3.4.2 Landscape categorization

The criteria of selection of three different landscape parameter sets, resulting in the three different landscape designs, were in part quantitative, such as for example the terrain characteristics expressed by landscape profile. Although the general geostatistical descriptors of terrain were not considered directly in the design process, the landscape profiles were specifically chosen in terms of *visual complexity*.

Landscape profile The progression of landscape elevation from the start to the end of the animation measured along the trajectory of movement (i.e. the profile graph of the trajectory of the observer over the landscape) does not allow us to have control of the characteristics of the full three-dimensional structure of the terrain that is visible during the fly-by.

However, the terrain profile is used in this study to simplify the conceptualization of the terrain. After all, it is the most significant piece of information in the entire terrain, because it is the one directly involved in the interaction between observer and terrain: in the terrain-following condition, the observer "goes up" if the profile "goes up" as well, even if to the right and to the left of the line of the profile deep cliffs might suddenly open up.

In other words, this experiment design has a minimal, but existing, degree of control on observer-terrain interaction, at the expense of a degree of control on the actual information available from the landscape, which is left open to randomness, necessary for ecological experimentation.

However, an analysis of the terrain information available along trajectories compared with the information of the rest of the terrain, would probably give the result that the two aspects are consistent with each other: "going up" in the profile results in a "going up" in the entire surface (e.g., a trajectory along a steep hill corresponds also to a steep hillside surface). This is probably due to intrinsic properties of the real-world terrain data used in this study.

In practice, two experiment conditions (*Plain Cruise* and *Ynez Peak*, see below) were chosen so that they respectively represented a stable, non-increasing profile, and a gradual, monotonically-rising profile. They were identified in real-world areas, respectively characterized by a flat plain and a hill. Such mathematical abstraction of profile characteristics will be useful afterwards in generalizing the results.

More precisely, the two trajectory types, *flat* and *rising*, result from a qualitative attempt at categorizing the observer's movements on the landscape into fundamental categories, or *primitives* of camera movement on the landscape, that in a previous experimental design comprised also *descending*, *overcoming minor obstacle* and *overcoming major obstacle*, concepts that lead to the idea of *visual complexity*. Although it will not be investigated here in detail, *visual complexity* represents a measure of the aesthetic potential of the landscape. It is not a geostatistical measure of terrain as a whole, but rather a measure that uses as determining factors the visual arrangement (e.g., occlusions) of the landscape.

In practice besides selecting an area in *Ynez Peak* where the desired monotonically-rising trajectory type could be applied, it was also possible to include a special effect of final *reveal* after the gradual hillside rising, where the limited visual range could be extended indefinitely after the top of the hill had been reached. Although the profiles are the control on the generation of the trajectory from the source of terrain form, special cases of *visual complexity* were added ad-hoc in anticipation of future designs.

Chapter 4

Pilot Experiments

A series of three pilot studies were carried out before the final experiment, based on a preliminary version of the following Methods Section, and aimed at developing a better design strategy.

In the first pilot test, 14 undergraduate and graduate students (11 males, 3 females) were selected. The experiment materials were made of two animations (LA-TF/HA-U), consisting of a rectilinear 3 Km flight across a canyon system on central Santa Catalina Island (CA). With respect to the following final experiment, the animations were of lower quality and less distinguishable as independent landscape experiences, motivating a more thorough design work as a follow-up. The main objective of the pilot was to test the overall procedure, and in particular the adequacy of the computer animations in allowing the subjects to remember details to be later reported in the questionnaires.

The results of the pilot indicated that the two experimental conditions (LA-TF and HA-U) elicit different landscape experiences at a significant (p<.1 and p<.05) level in at least two close-ended questions, respectively suggesting that an LA-TF stimulates less curiosity for newly revealed parts of the landscape and a weaker feeling of possessing navigational knowledge than HA-U. The latter result confirms the superiority of high elevation views in conferring at least an impression of layout knowledge, while the first result is in contrast with an idea of landscape that elicits more curiosity because it is revealed over time while advancing in a trajectory close to the ground. One could infer that a lack of information does not necessarily elicit curiosity, and the outcomes of the flow of information in a landscape animation appeared complex.

Participants seemed in general to be able to encode a good level of detail in their maps, even if the individual differences were substantial and appeared stronger than the differences across experimental conditions. The maps were not analyzed, but it was possible to determine the variable extent to which the participants detected the characteristics of the experimental condition. In summary the pilot suggested that the approach was feasible, and the procedure was able to extract useful information producing complex results, although the analysis and interpretation could be anticipated as difficult.

The second pilot study was entirely addressed to the verbal component of the experiment, that is, the formulation and the understanding of the questionnaire. A group of 10 undergraduate students were individually introduced into an informal but specific conversation aimed at evaluating their understanding of the questions, after being exposed to the then already completed animations of the main experiment. Besides gaining a better idea of the general characteristics of the participants, and correcting verbally confounded questions, the pilot was useful to fine tune the wording of the required concepts to be investigated, by means of a trade-off between the participant familiarity with the textual format, and the linguistic precision in referring to the entity being measured.

A third pilot study involved three undergraduate students. It was aimed at checking whether the overall testing procedure, consisting of three animations and three questionnaires to be filled in, could be completed in the allotted test time. It also allowed a complete execution of the procedure, inclusive of the multimedia presentation and all the informational materials such as informed consent and oral briefings and debriefings.

Chapter 5

Methods

5.1 Design

This experimental design comprised two main variables, (1) viewer (and helicopter) altitude and trajectory type, and (2) landscape type. The first variable had two levels, namely (1) low altitude and terrain-following, and (2) high altitude and uniform. The second variable had three levels (landscapes), namely (1) *Plain Cruise*, a uniform plain-based landscape, (2) *Silver Canyon*, a narrow valley, and (3) *Ynez Peak*, a mountain (see Figure 5.1).

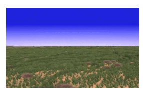
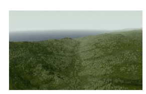
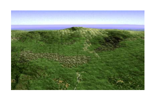
CONDITIONS LANDSCAPE/ TRAJECTORY	**P**lain **C**ruise	**S**ilver **C**anyon	**Y**nez **P**eak
Low **A**ltitude- **T**errain **F**ollowing	 PC/LA-TF	 SC/LA-TF	 YP/LA-TF
High **A**ltitude- **U**niform	 PC/HA-U	 SC/HA-U	 YP/HA-U

Figure 5.1: Summary of experimental design

5.2 Participants

The number of participants in the final experiment was 36 (22 males and 14 females, distributed in roughly equal proportion in the two between-subject conditions). The average age was 21 years old. Participants were drawn from the undergraduate research pool available at the UCSB Department of Geography. The pool was mainly composed by students taking the introductory Human Geography class, and also by a few junior and senior students taking more advanced classes (Applications of GIS, and Geovisualization).

5.3 Materials

5.3.1 Landscape stimuli

Data sources

The landscapes used in this study were selected from a terrain database composed of two datasets: the Conception Coast dataset, and the Santa Catalina Island dataset. The Conception Coast dataset was used to design two landscapes: *Plain Cruise*, located in a large

Figure 5.2: General location map

plain in the north-western area of the dataset (indicated as the San Luis Obispo area), and *Ynez Peak*, on the transverse mountain range close to the center of the dataset. The Santa Catalina Island dataset, covering a much smaller island area in front of the south-eastern coastline of the Conception Coast dataset, was used only for *Silver Canyon*, corresponding to an area on the south-eastern tip of Santa Catalina Island.

Figure 5.2 shows the two entire datasets, and the inset maps represent the specific landscape areas being used.

Conception Coast dataset The Conception Coast dataset is a 60 meters resolution Digital Elevation Model (DEM) set, based on freely available USGS (United States Geological Survey) DEMs, which was provided by the environmental organization ConceptionCoast.org as a single large DEM.

The original DEM was in the Albers projection, which had to be re-projected in latitude-longitude coordinates (i.e., the projection used by the 3DNature's visualization software World Construction Set v.3 on which the visualizations were made). The latter operation was carried out using the Grid re-projection utility available in ESRI Arc/INFO Toolbox. The re-projected DEM was then displayed using ESRI ArcView 3.1 and then saved in Arc ASCII format for import into World Construction Set.

Using the import functions available in World Construction Set the original large DEM was segmented in a regular grid of 135 distinct but contiguous DEMs, approximately consisting of 300x300 cells, and maintaining the 60 meters resolution of the original dataset. Indicatively, just one of the final DEMs was sufficient to completely cover one designed areas.

Santa Catalina Island dataset The Santa Catalina Island dataset was not publicly available, and was provided by Dr. Bill Bushing, formerly at the Catalina Conservancy. It was originally produced from the digitization of USGS topographic maps of the area. The dataset has a cell resolution of 20 meters.

The original dataset came as a single ESRI Arc/INFO Grid file, which was loaded in ESRI ArcView 3.1 and exported to Arc ASCII format.

Before the import in World Construction Set, it was necessary to modify the individual cell values for the non-land areas of the dataset because they were initially set to a zero value. This interfered with the realistic gradient rendering of the ocean, therefore a text editor was used to set the bathimetry to a lower value that produced in the visualization a deep blue color.

The preprocessed DEM was converted in World Construction Set DEM format, resulting in 12 distinct but contiguous, and slightly rectangular, DEMs, all correctly georeferenced. Additionally to this land base, several additional DEMs were added in the western zone by means of creating new oceanic DEMs (with constant negative elevation value) that were re-georeferenced precisely at the external boundary of the other ocean-defining DEMs. In so doing the extent of the waters surrounding the island was enlarged. This in turn allowed the animations not to show a sudden and incorrect "end of the world" effect, which would have appeared in the final animation if the ocean gave way to the sky gradient below the horizon line.

Strategies for dataset enhancement In order to keep the rendering times low, it was preferred not to fractally sub-sample every individual DEM into a new set of DEMs having four times the spatial resolution of the original DEM. To increase resolution in the dataset, which in some cases determines the overall realism of a scene, a less computationally "expensive" solution was preferred. Fractal techniques added random detail to the coarse terrain structure defined by the data itself, process carried out at the final rendering step and not as a data preparation procedure. Determining the ideal Fractal Depth value consisted of a trial-and-error process that involved considering a trade-off between rendering time and final image quality.

On the trade-off an intermediate point was chosen, equal to a Fractal Depth of 6 for Conception Coast, and 5 for Santa Catalina Island, that leaned towards moderate rendering costs. This offered an apparent ground resolution of sub-meter level, approximately equal for both datasets.

This simplifying solution made the study feasible, considering the almost prohibitive (in terms of time) rendering costs of six animations, besides the other additional and numerous trial versions. However, although some of the low altitude animations showed occasional ground polygons, unavoidable without higher fractal depths of subsamplings, the overall quality was considered to be good, and adequate for the purposes of the study.

Landscape 1: *Plain Cruise*

Design objectives In the first landscape, named *Plain Cruise*, the objective of the design process was to provide the participant with stimuli originated from a flat terrain, while the non-controlled variables of land cover and general appearance were decided to give the impression of a somewhat human-made and agricultural scenery, although not specifically urban.

Terrain structure The topography of *Plain Cruise* is based on the Conception Coast dataset. The area that was selected presents an approximately flat terrain form, although at a much closer scrutiny it results to be sloping down very gently towards the West. On the Easter horizon, the flat plain gives way to some hilly terrain.

Plain Cruise topography was chosen to offer the least *visual complexity* to the participant of the three landscapes considered. There are

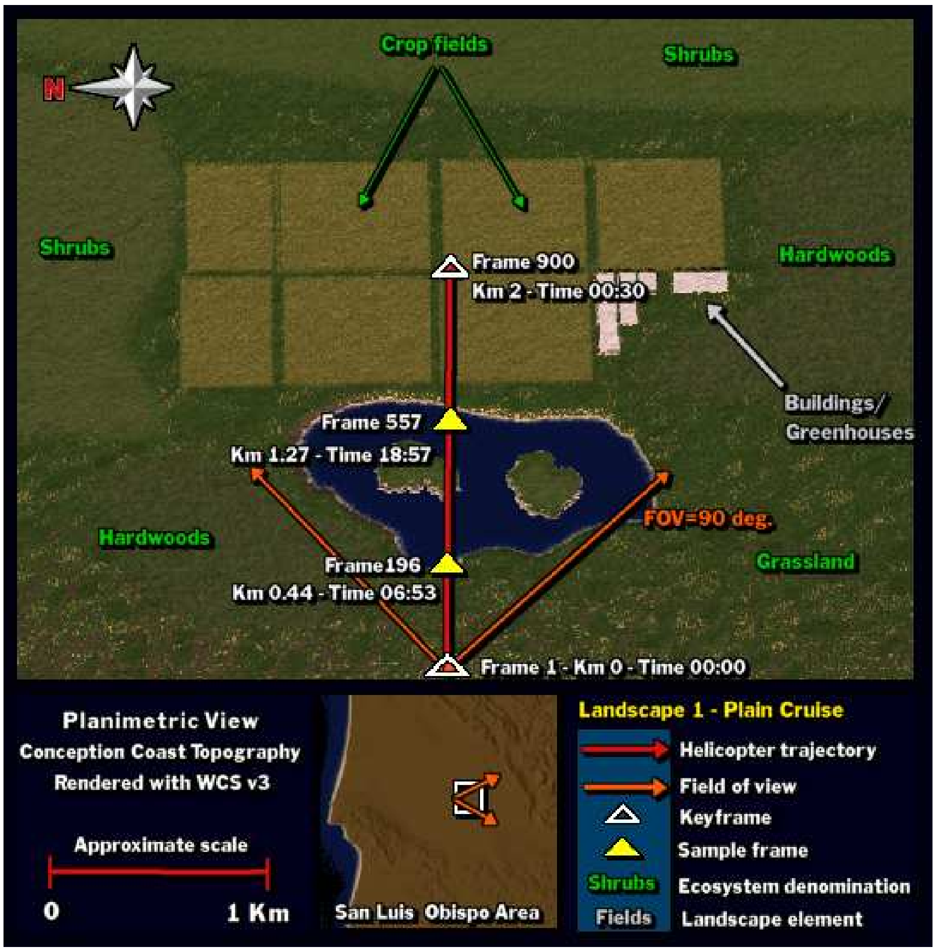
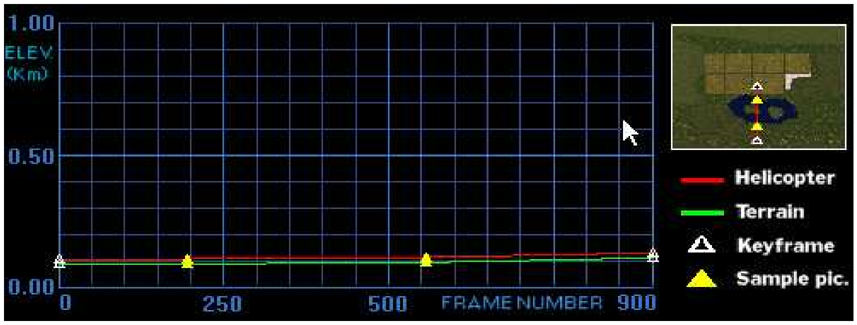
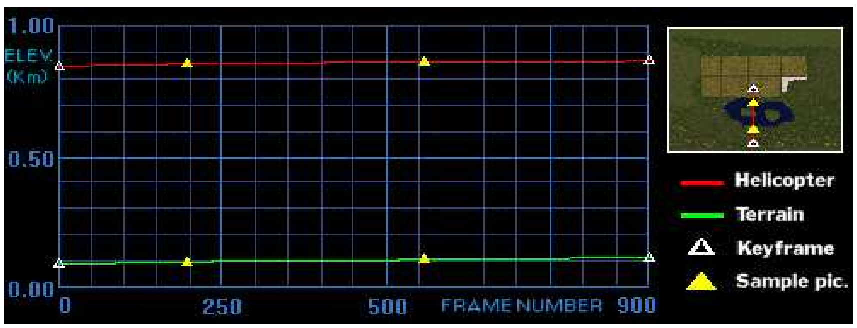


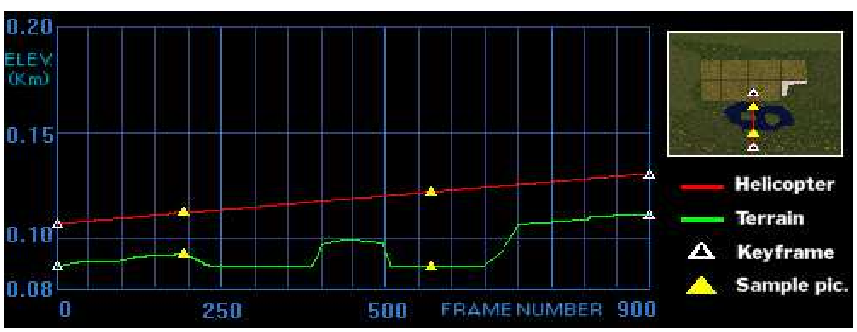
Figure 5.3: *Plain Cruise* site map



(a) Low Terrain Following

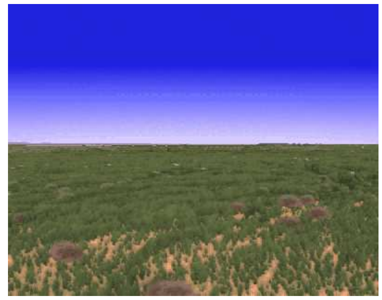


(b) High Uniform

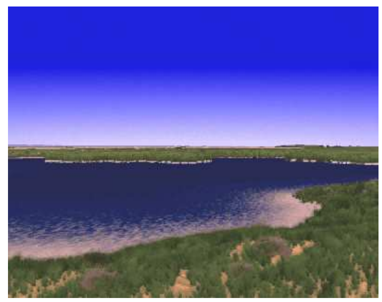


(c) Low Terrain Following Zoom 5X

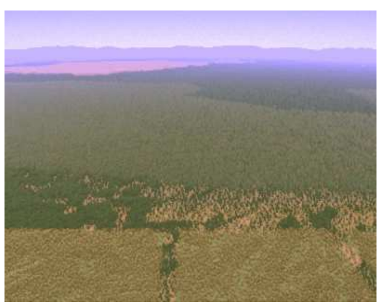
Figure 5.4: *Plain Cruise* profile graphs



(a) HA-U - Frame 000 (b) LA-TF - Frame 000



(c) HA-U - Frame 196 (d) LA-TF - Frame 196



(e) HA-U - Frame 900 (f) LA-TF - Frame 900

Figure 5.5: *Plain Cruise* sample frames

no occlusions throughout the animation, in both conditions, and no topographical mystery effect is proposed since there are not any suitable topographic configurations.

Landscape design elements In this landscape, as in the other two for that matter, the non-controlled design elements were not chosen to obtain a replica of the ecological characteristics of the local environment represented, but to define useful and distinguished stimuli to show to the participants.

The landscape elements added on top of the topographic data comprise also an artificial lake, created by digitization and elevation manipulation. In the middle of the lake, two irregular islands were added, by means of digitization and areal addition of elevation.

The "universal" ground cover was set to low grass. On the back and on the sides of the lake, several irregular "specific" land cover regions were manually digitized. They were characterized by different combinations of hardwoods, bushes, grasses, rocks, and so on. In addition, a few rectangular fields, set to be filled with corn-like vegetation, were arranged in two rows transversally to the direction of motion, accompanied by sketched buildings/greenhouses.

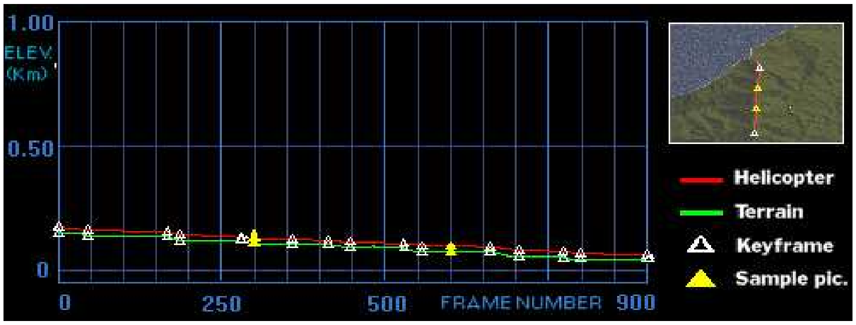
The animation was generated as if the local time was 3:00pm on July 11th. The sun was producing intense illumination from an almost vertical position, thus imposing a “flattening” effect on all landscape features. For a general view of the area, see Figure 5.3.

Trajectories implementation The trajectories designed for the *Plain Cruise* landscape are shown in Figure 5.4. The HA-U condition consists of a straight trajectory at an average altitude of 761 meters from the ground. In the LA-TF condition the trajectory is shown to be practically flat (it is sloping upwards by a minimal percentage) and always parallel to the ground, although it is not responsive of subtle variations of topography existing in designed areas. Sample frames of the two animations are shown in Figure 5.5.

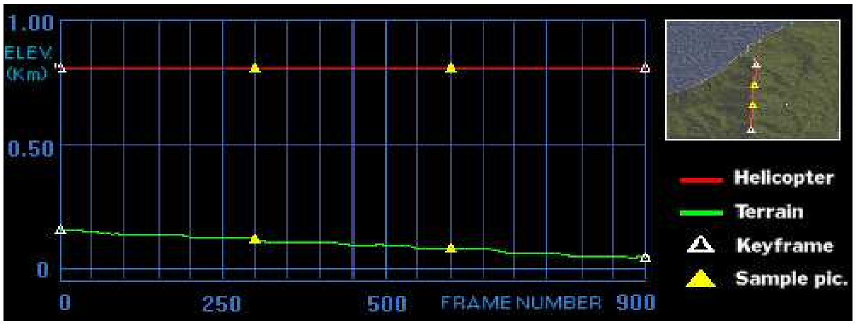
Landscape 2: *Silver Canyon*

Design objectives The *Silver Canyon* landscape was specifically designed to address a particular aspect of visual landscape design mainly related to the sense of closure offered by narrow valleys to observers on the ground. Second, the topographical structure of a valley, progressing

Figure 5.6: *Silver Canyon* site map



(a) Low Terrain Following



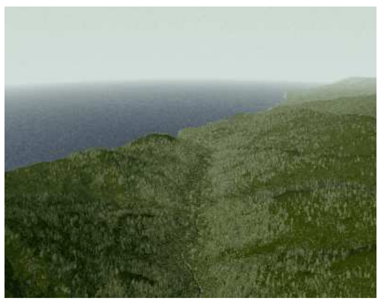
(b) High Uniform

(c) Low Terrain Following Zoom 5X

Figure 5.7: *Silver Canyon* profile graphs

(a) HA-U Frame 000

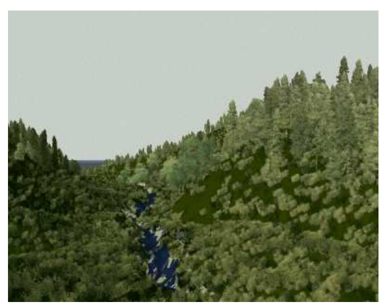
(b) LA-TF - Frame 000



(c) HA-U Frame 300

(d) LA-TF - Frame 300

(e) HA-U Frame 900



(f) LA-TF - Frame 900

Figure 5.8: *Silver Canyon* sample frames

downslope towards the ocean would have allowed us to investigate the terrain profile condition of *landform descent*. Third, the special site configuration due to the closeness to the ocean, and moreover some more specific definition of the non-controlled components of the landscape, allowed us to have a "meaningful" landscape to show.

Terrain structure After an extensive virtual exploration of the particularly rugged topography of Santa Catalina Island, the *Silver Canyon* area, in the southwestern part of the island, was selected. *Silver Canyon* is a very narrow and long canyon, almost perfectly straight, oriented NE-SW, and leading directly into the ocean. On both sides of *Silver Canyon*, very rugged topography can be found. The valley itself is characterized by a thalweg that gradually descends down to the ocean in an almost stepped fashion (probably due to the digital topographic source).

The *visual complexity* of this landscape is not due to particular landscape configurations encountered along the direction of motion, but to the steep slopes on both sides of the valley, that are perceivable as such only in one of the two trajectory conditions (see Figure 5.6).

Landscape design elements *Silver Canyon* is probably the landscape where it is most evident that the original characteristics of the source environment (in this case, Santa Catalina Island), have not been replicated, but only used and transformed according to design choices.

The "universal" land cover was set to a conifer forest type, reminiscent of Oregon or British Columbia landscapes, which gave the landscape a distinct look with respect to the other two. "Specific" land covers were digitized along the thalweg of the valley, and in particular hardwood woodlands areas were defined to suggest some sort of riparian corridor.

A stream was manually digitized along the line of maximum slope of the thalweg of the valley. Together with the topography, *Silver Canyon* offered also the presence of the ocean, visible in the HA-U condition only, taking up a large part of the last frames of the animation (there are also a few ocean pixels in the last frame of LA-TF).

The general look of *Silver Canyon* was made to recreate a gloomy morning (9:00am, May 28th) in some area of the Pacific Northwest. The more contrasted shadows of the morning time tend to exaggerate the topography, although a preliminary design set in the evening was discarded for the too dramatic differentiation between the opposite slopes of the valley.

An atmospheric effect, haze, was added to complete the ambience, but also to hide the so-called "end-of-the-world" effect, noticeable when a perspective view is set on a dataset that does not reach in extent the horizon line.

Trajectories implementation The trajectories designed for the *Silver Canyon* landscape are shown in Figure 5.7. The HA-U condition for *Silver Canyon* is described by a trajectory at a constant altitude of 802 meters, that reflects the standard value of altitude above the ground of 763 meters, that in this case was measured from the end (and lowest part) of the terrain profile. The trajectory can be considered straight, although it was minimally arcuated to follow the direction of the valley.

The LA-TF condition is characterized by a reference distance from the ground of 20 meters. The graph showing the 5-times vertical exaggeration on that condition indicates how the trajectory so defined was adapted to offer, at the same time of the distance-from-ground constraint, a non-discontinuous and reasonably gentle motion to the observer. A sample of the animations' frames is in Figure 5.8.

Landscape 3 - *Ynez Peak*

Design objectives The landscape of *Ynez Peak* (short version for *Santa Ynez Peak*, the local highest point of Santa Ynez Mountains, directly flown over in the animations) was selected to be part of the final experiment design mainly for its distinct topography and *visual complexity*. Again, the haphazardly-placed landscape design elements did not aim at replicating the local ecology, but to create a sufficient visual variety.

Terrain structure Topographically, *Ynez Peak* offered a good occasion to examine a pure *landform rising* structure type of landscape, which in other sites could not be found for multiple reasons, including the presence of local irregularities which denied the possibility of using a completely monotonic and increasing surface profile.

Ynez Peak also offered the interesting landscape configuration based on the arrangement of a perfectly transversal mountain range, separating an internal valley from the ocean. Such configuration allowed us to have the aesthetical effect of "landscape reveal", whereby the short

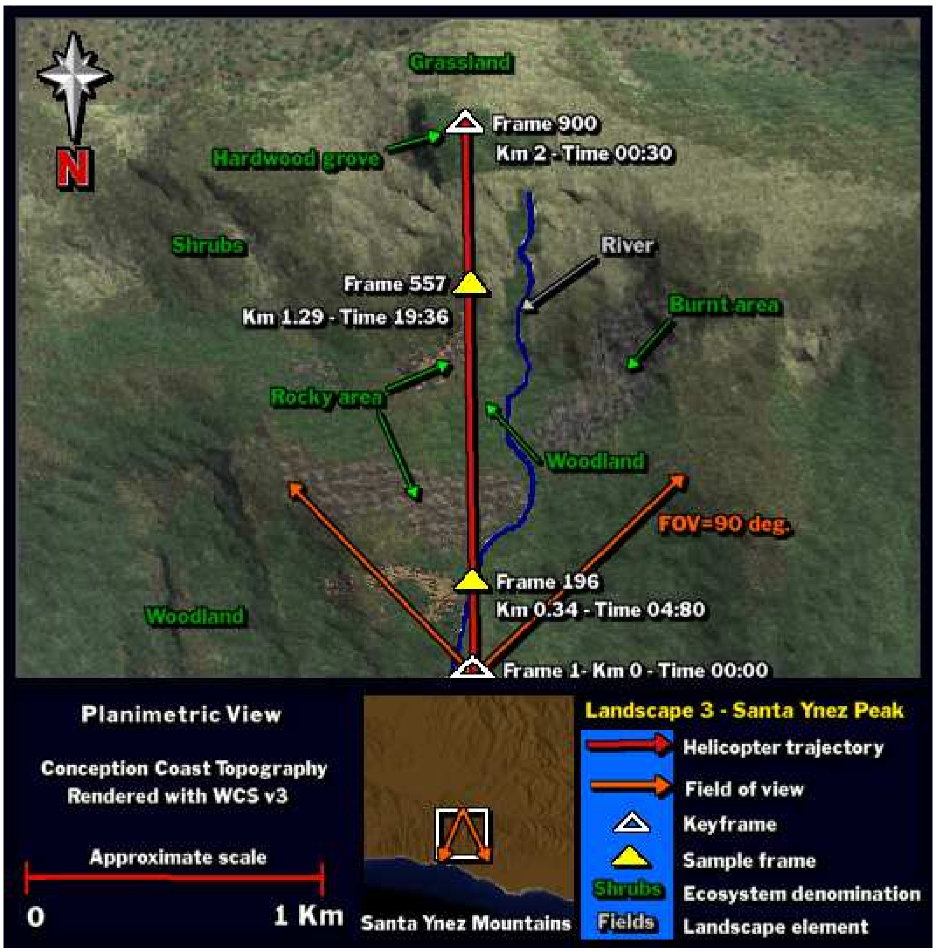
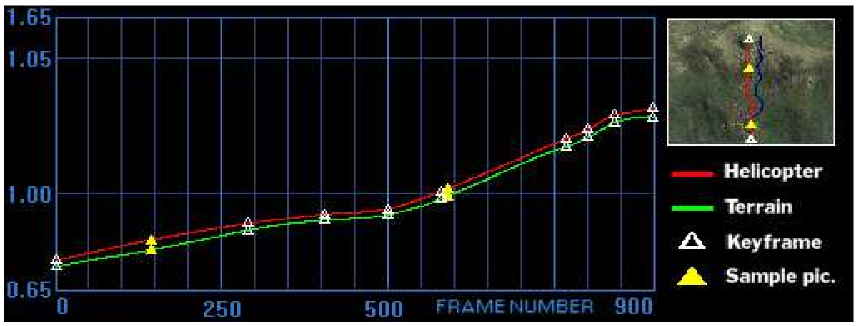
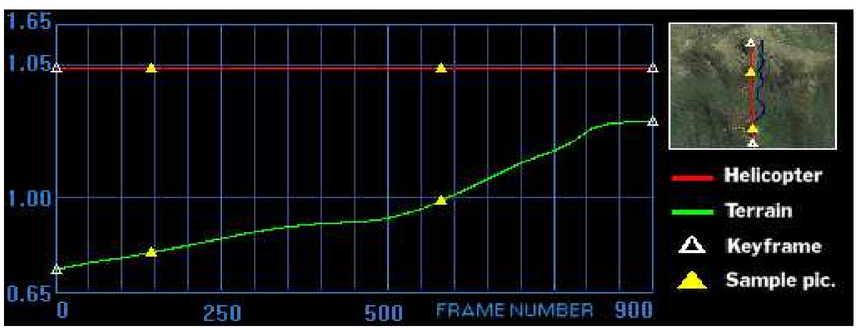


Figure 5.9: *Ynez Peak* site map



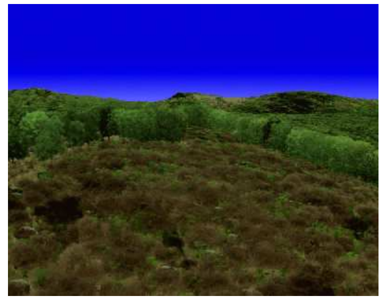
(a) Low Terrain Following



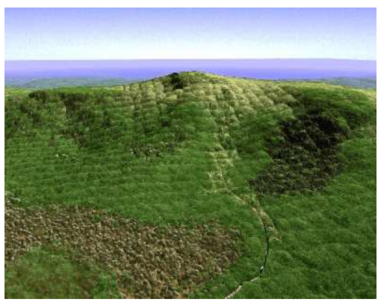
(b) High Uniform

Figure 5.10: *Ynez Peak* profile graphs

(a) HA-U Frame 000



(b) LA-TF - Frame 000



(c) HA-U Frame 145

(d) LA-TF - Frame 145

(e) HA-U Frame 899

(f) LA-TF - Frame 899

Figure 5.11: *Ynez Peak* sample frames

ranged-view of the mountain while climbing it, gave suddenly away to the view of the valley and the ocean below.

Finally, the fact that the animations took place on the opposite side of the Santa Ynez Mountains with respect to the UCSB campus reduced the chance for participants to be excessively familiar with the area (if the campus was included as a landscape element, it would have been visible in the very last frames of the animation).

Landscape design elements The "universal" land cover of *Ynez Peak* is subdivided in a series of elevation-based vegetation bands that define a low elevation (base of the mountain) cover of Oak Woodland, a mid-elevation (center part of the hillside) cover of Shrubs, and a high elevation (hilltop) cover of Grass.

Specific land covers were digitized and defined on the landscape, as visible on the location map in Figure 5.9. They comprise a burnt forest area, a local concentration of oak woodland (outside the "universal" bounds of the same land cover), and extended areas covered with rocks and grass (imaginatively, some sort of rockslide). The density of the vegetation was set very high to obtain a "lush" effect.

A stream was digitized, from the base of the mountain in front of the observer, to the western side of the mountain, close to the top. The stream was modelled so that it cuts rather deeply the mountainside, creating in the end a strong separation between the two sides of the thick vegetation.

The Sun position was set to the early afternoon of the summer solstice, thus characterized by very intense illumination, bright colors, and limited shadows extent.

Trajectories implementation The trajectories used in *Ynez Peak* are shown in Figure 5.10. The HA-U trajectory is characterized by a uniform flight at the constant altitude of 1490 meters, which means an actual distance from the ground corresponding to the one used in other landscape conditions.

The LA-TF trajectory is constantly placed at 20 meters from the ground, and follows the profile of the landscape, which is rather smooth. There is no need to show a vertically exaggerated LA-TF graph, since there are no small scale features characterizing the landscape profile and the trajectory. Sample frames of the two animations are in Figure

5.11.

5.3.2 Instruments: questionnaire

The questionnaire utilized to test separately each landscape experience was made of 43 questions, mostly written as Likert scales, but also open ended, or based on graphical sketches (see Appendix). They investigate several different semantic areas of landscape experience, whose categories can be broadly broken down as follows:

- General preference and specific preference, in general in the form of like or dislike of the landscape as a whole or in terms of its constituting elements. This includes also the trajectory as an item on which the participant can express a preference (Q1-Q17).

- Spatial knowledge questions, including the ability to remember the topographical layout of the landscape as altimetry but also as the arrangement of the constituting elements. The same consideration is extended to the participant's knowledge of the trajectory along which the landscape was viewed, including profiling and relationship with the ground (Q18-Q21).

- Aesthetics, and self-reported impressions referring to other constructs such as presence and excitement. The term aesthetics incorporates the direct measurement of the four Kaplan's aesthetical factors (*coherence*, *complexity*, *legibility*, *mystery*) (Q22-Q43).

The questionnaire aims at collecting data on the totality of the participant's landscape experience, which, considering the framework of this thesis, is largely mediated by constructs related to aesthetics. The questionnaire is not the result of design based on statistical analyses, ensuring independency and a degree of control on the relationship between questions and constructs. Such analysis was considered excessively demanding in terms of the required testing procedure, which was only preliminary to the core of this research.

The questionnaire is instead an extensive verbal articulation of mainly aesthetical constructs all derived from the literature, which however were extended conceptually to form viable questions in ways that were aimed at non distorting the original idea. For example, a way to ask about complexity was found in the Likert scale statements "there were too many things in the landscape" and, in the following question, "there was too little variety". "Number of things" and "Variety" were both correlates of complexity, although the relationship was intuitive and structured qualitatively. In the end, questions were put down in common English words, and organized in key statements, previously fine tuned in wording by means of specific pilot tests (see Chapter Pilot Experiments).

The questions and sketch maps for the spatial knowledge section of the questionnaire for each participant and condition were coded by means of grading schemes aimed at capturing the quantity of landscape elements being drawn. Each landscape condition had a different grading scheme: PC presented a total of 19 elements (crop fields, lake, islands, etc.), SC was limited to a maximum of 12 elements (topographic features like valley sides, specific ecosystems, etc.), and for YP the amount of elements was 15 (river, ecosystems, ocean, etc.). Since the analysis was conducted across-trajectories and not across-landscape, the different amount of elements was not a limitation of the procedure, but rather a feature that gave adaptivity in the classification of each landscape.

The second part of the data collected for spatial knowledge refers to the accuracy of the depiction of landscape elements in the sketch maps. This was not meant to be a drawing skill test, rather it measured the precision with which the shapes were drawn, and how accurate were boundaries and location of areal features like topography and ecosystem extensions. Accuracy was measured for each class of items included in the respective landscape design template, assigning scores from 0 as "not drawn", to 3 as "perfectly drawn".

5.4 Procedure

The experiments were carried out using an 800 Mhz laptop PC, running Windows ME and equipped with the broadcast multimedia presentation software SCALA iplaySTUDIO (by SCALA Inc.). The computer had an LCD screen with a diagonal of 14.1 inches, and displayed the animations in 24-bit true color. The location of the experiment was the RUSCC lab, made available at the UCSB Department of Geography. The laptop was set on top of a table and the participant sat on a chair in front of it at normal operating distance.

The computer presentation that led the participants, one by one, through the experiment repeated first the oral and written briefing instructions. The participant had to imagine being in the cockpit of a helicopter flying over several landscapes, which were declared to be taken from the real world, although generated on a computer. It was suggested to the participant to be prepared to report her experience with the landscapes being shown, whose number, together with the number of questionnaires and the overall sequence of the experiment, was anticipated. Before being exposed to the first landscape, the participant was already informed of the fact that she had to draw a map of the landscape. In fact, although the order of the 3 landscapes was fully counterbalanced across the entire pool of participants, there was an asymmetry in instructions that made the participant unaware she would have to draw the map in the first questionnaire, and instead allowed her to know the details of the task just after the first questionnaire, for the remaining two questionnaires.

The mouse click was used to progress to the next page, and led the participant to view each of the three animations twice, and then to complete the questionnaire on paper after each pair of animations. After the third pair of animations was completed by the participant, she had to fill in a questionnaire on their personal background.

During the entire experimentation the system ran smoothly, and all the animations were displayed in exactly the same fashion at a full frame rate.

Chapter 6

Results

The results comprise the responses to the Likert scale questions, concerning general preference, specific preference, aesthetics and sense of place. The responses to questions are considered individually, and are statistically analyzed by means of two-tailed independent sample *t-tests*, entirely within landscape conditions and across trajectory conditions. The results also comprise the responses to the spatial knowledge questions hinging upon the sketch maps drawn by participants in the median section of the questionnaire. In particular, the spatial knowledge questions consider the two fundamental elements of quantitative landscape element detection, recognition and report, and the average accuracy level in reporting them on the sketch maps.

The response of participants to specific designs and conditions resulted extremely patterned. The general preference question (Q1) was the one with the widest scope in the questionnaire, since it summarized the totality of the aesthetical response to the landscape stimuli. A significant result was not predicted before the tests, since it incorporated the variance generated by many contributing variables. The YP/LA-TF landscape condition was reported significantly more liked than the HA-U condition ($p<.05$), while the effect was not found in similar across-trajectory comparisons for SC and PC.

The question addressing the development of a condition of mystery (Q45) directs our attention to the aesthetical effect primarily consequential to the presence of a high degree of *visual complexity* in the landscape. Reflecting the pattern of Q1, the YP/LA-TF condition appears to generate a significantly higher effect of mystery than the corresponding HA-U ($p<.01$). Question 39, concerning the level of excitement of the participant, reached significance also in the YP/LA-TF condition, more exciting than HA-U ($p<.05$).

Interestingly, question 29, asking about experiencing a surprise effect at the end of the animation, did not result significant in any of the conditions, not even in the YP condition were the animation was constructed especially to generate surprise through a specific landscape "reveal" effect.

The SC landscape was primarily designed to investigate the influence of orographic features on landscape perception, and two ad-hoc questions were added to the questionnaire concerning this orographic perceptual effect. Interestingly, the responses allowed us to find a significant difference between the SC/LA-TF and HA-U in question 5 ($p<.05$), indicating a stronger preference for the level of closeness in the LA-TF condition contrasted with HA-U. However it must be noted that to several subjects did not seem clear what was meant by a "closed" landscape, and the minimal explanation in the testing phase might have in part affected the results.

The "sheltering" pattern becomes even clearer in the specific question 33 asking whether the participant felt sheltered by the landscape. Sheltering in the SC/LA-TF condition, characterized by high valley walls to the left and to the right of the moving observer, was experienced significantly stronger than in the corresponding HA-U condition

(p<.01). This pattern was not repeated in any of the other two landscape conditions (as expected).

The direct questions generated from the four Kaplan's factors (used as constructs) did not produce significant differences across trajectory conditions, except for those measuring complexity. In fact, the two partially overlapping questions on the degree of variety in the scene, and on the quantity of elements present, gave converging results, indicating that the landscape in PC/LA-TF appears significantly more complex than the same landscape seen in the HA-U condition (Q24 p<.01, Q25 p<.01)

While considering the across-trajectories differences of the specific preference questions, the results seem to be the consequence of the striking changes in appearance of landscape when altitude is appropriately manipulated. For example, the overall relief of the PC landscape was perceived to be significantly higher in HA-U condition than in LA-TF (Q6, p<.01). In light of the flatness of the plain and the mountains on the horizon the result reflects more of the elements being visible than a different evaluation of the elevation of the same elements.

Along the same lines, the specific preference questions show how the difference across trajectory conditions are due to the specific visual structure of the landscape. Because of this reason vegetation is more preferred in PC/HA-U than in LA-TF (Q10, $p<.05$), and, conversely, preferred more in SC/LA-TF than in HA-U (Q10, $p<.01$). Also, roughness is significantly preferred in YP/HA-U, compared to LA-TF (Q9, $p<.05$).

The questions related to sense of place gave significant effects in the "uniqueness" question (Q35), which indicates that, in the HA-U condition, the artificially patterned PC landscape resulted more convincingly unique than in the LA-TF condition ($p<.01$).

Some questions referred to the concept of perceptual satisfaction with the landscape experience being shown. The question addressing the degree of satisfaction with the extension of the viewshed available from the animations resulted in a significantly different self-report. Specifically, the SC and YP conditions both showed how the two LA-TF conditions generated dissatisfaction with the amount of information available (Q41, SC $p<.01$, YP $p<.01$). The related concept of desiring to know more of the landscape (Q43) gives an inverted pattern, since LA-TF conditions for SC ($p<.05$) and YP ($p<.05$) clearly indicate how the lower altitudes elicit more curiosity for generic information for the landscape, but also, in the case of SC (Q40, $p<.05$), for further visual exploration. Interestingly, PC does not offer significant results across condition in these respects.

As a general effect of the animated stimuli, the speed of the animation (Q46), related to the concept of information rate, was reported as consistently different across trajectory conditions in all the three landscape conditions. In fact, LA-TF flights always seemed less excessively slow than HA-U (PC $p<.05$, SC $p<.001$, YP $p<.01$), although the actual flying speeds were virtually identical. The confound constituted by the observer moving at higher speed when climbing hills (see Methods) does not interfere substantially with the result, also considering the non-confounded conditions of PC and SC giving the same result as the confounded YP.

In the case of the spatial knowledge questions, the analysis of the number of elements consisted in running a *t-test* comparing the total number of objects detected in the two conditions (LA-TF and HA-U) by each participant, to detect differences in the multiple conditions.

The main finding of this section is that the number of landscape elements detected in PC/HA-U is significantly different than in LA-TF ($p<.001$), indicating a better capacity in detecting and remembering the elements of the landscape when flying high. Conversely, the other landscape conditions did not show a similar effect.

The accuracy scoring analysis was also ran by means of a *t-test* that compared the average accuracy score of each participant in the entire set of accuracy variables, across trajectory conditions The PC/HA-U condition did not allowed participants to score significantly higher in accuracy than in the LA-TF condition, so that PC/HA-U is eliciting only the detection of a higher number of elements. This supports in part the ability of layout view to increase the chances of gaining a better spatial knowledge.

Chapter 7

Discussion

The patterned results presented in the previous Chapter suggest a solution to the problem of whether trajectory of approach is or is not a factor influencing landscape experience. The direct, between-subject comparison of trajectory conditions (LA-TF and HA-U) indicates several interesting cases in which the reported landscape experience is significantly different. This Section will show how this behavior resulted coherent with the principles reviewed in the literature review, and with the theoretical considerations documented in the conceptual framework.

By means of considering that *visual complexity* underlies the nature and degree of the aesthetical response to landscape, we have empirically measured such influence by controlling the characteristics of the terrain of the designed landscape being filmed. In this context it was also suggested that the YP/LA-TF condition was the most visually complex amongst the three, specifically in terms of how the visibility of topography varies dynamically during exploration in time. PC had instead a topography which was the least visually complex. It must be stressed that the other YP trajectory condition (HA-U) offers a completely different complexity pattern, since the trajectory comes in touch with very little of the topographical *visual complexity* characterizing the landscape. In fact, the helicopter flies very high, without ever encountering temporary occlusions, reveal effects, and subtle changes in terrain.

The empirical results provide converging evidence of the striking difference existing between experiences done above the same landscape but along different trajectories. The interesting fact that, in the YP case, LA-TF is significantly liked more than HA-U, combines with the lack of a clear effect in the other two conditions. It is therefore suggested that even the most general measure of preference (that is, like or dislike) might have a different outcome in a given landscape according to the trajectory being used. Along these lines, the same YP/LA-TF trajectory is able to instill more excitement and to create more mystery than the corresponding HA-U. The latter effect clearly indicates how the higher *visual complexity* of YP was directly measured in terms of the strongly correlated mystery factor. We suggest that mystery perception is the natural experiential aspect of the more implicit concept of *visual complexity*. In other words, a high *visual complexity* creates a better articulation of landscape features for mystery to be perceived and to have a stronger psychological impact upon the observer.

However, the mystery effect is empirically detectable on a landscape characterized by high *visual complexity*, but only if the trajectory of the viewpoint crosses the spaces in which such complexity is explicitly manifest and experienceable in the form of partial or total occlusions, intriguing arrangements and accessibility of distance information: in conclusion, in a form useful for triggering survival-based activity.

Certainly it is true that terrain creates the highest degree of complexity amongst all contributing factors to *visual complexity* in a landscape. If a trajectory follows closely the ground, such as the LA-TF trajectories, there is a higher chance to be confronted with mystery, aesthetical pleasure, curiosity and intense feelings. This consideration naturally stems from the fact that a landscape animation does not imply necessarily a trajectory of flight functionally related to the terrain (such as a TF condition), but rather just a viewpoint moving above the terrain in a terrain-independent fashion.

In a mathematical generalization, it is argued that if a trajectory is a generic mathematical function of terrain form

$$\text{trajectory} = \text{f(terrain)} \tag{7.0.1}$$

it is easier for it to be closer to those aerial spaces appearing more perceptually interesting, stemming from the accessibility to higher terrain complexity.

The experimental design does not offer a complete empirical support to this idea, since the TF condition is also confounded by the LA component. However it is expected that in a future study on functional terrain trajectories, terrain-independent trajectories will be found less able to obtain visual access to landscape topographical complexity.

Visual complexity is also the source of other explicit effects, such as the sheltering effect in the SC landscape. To our knowledge there are not empirical investigations on the sheltering effect, which is mostly an architectural and visual design concept which is most often left in its qualitative, albeit useful, form. The clear sheltering effect is detected in clear correlation with the physical characteristics of the canyon landscape, that is, present when the canyon walls were visually sheltering, and it is not detectable in any other condition. This is another confirmation of how the spectrum of perceptual experiences is strongly correlated with the characteristics of the landscape, and specifically terrain. In fact, the latter is a determining entity in landscape experience.

In general the comparison between the effects on spatial knowledge of the high layout view, versus the low altitude first person horizontal perspective, gave the expected results. Almost as a dual, or an opposite, of perception and aesthetics, spatial knowledge is best gained when the *visual complexity* is simplified or experienced from a more advantageous viewpoint, and when consequentially there is not an involving dynamic experience with the landscape. The fact that in both SC/LA-TF and YP/LA-TF participants demanded for a higher vantage point for a future better navigation on the ground is indicative of how altitude is a fundamental correlate of the visual accessibility of landscape to gain spatial knowledge for wayfinding and navigation.

It should be noticed how the grading scheme has in part determined the statistical pattern, since PC was much more itemized (many crop fields, vegetation patterns, island). In HA the participant could simply tap in a more vast quantity of pick-up-able landscape elements than the corresponding LA-TF condition. Also, the less itemized forests of SC and the irregular ground patterns of YP allowed less numerical counts. In other words, across landscape condition, elements pick-up varies with the ability of landscape to be subdivided in many constituents elements that can be singled out (consider that, for example, many similar trees are seen as one forest, as in the case of SC).

In other words, HA (with the additional component of the slightly reclined pitch of the helicopter) produces in the observer less involvement, excitement, immersion in the landscape, and instead grants visual accessibility to what is not otherwise visible in other conditions. However, the gain with HA-U trajectories reaches "critical mass" only with certain landscape configurations, such as the more artificial PC, since in other landscape configurations is harder to distinguish enumerable features from confusing vegetation aggregates and over-complex topographic arrays of features.

In summary, the main finding of this study is that any landscape is characterized by a degree and a type of *visual complexity*, which in turn projects around it a space that determines an accessibility to such complexity. Explorers negotiate visual access with the complexity of the landscape and their movement grants them access to certain aspects and not others. Such accessibility space is highly patterned, and the striking differences between HA and LA show that the approach to landscape structures the experience of the approach itself. The experiential differences stemming from the patterns of the accessibility space comprise all component of human psychological experience, including perceptions, spatial knowledge and feelings. Once a trajectory on a landscape is decided, the landscape becomes accessible in a certain way, which is defined by the implicit complexity of the landscape and the trajectory negotiating with it. The concept of filtering summarizes the previous considerations, by stating how the selection of actual trajectories from all the possible (and impossible) ones allows to exploit different areas of this visual accessibility space according to what we want to know about the landscape.

Chapter 8

Conclusions

Landscape is the result of a process of visual selection of the environment that contributed to the evolution and survival of the human race. The presence of evolutionary roots in landscape can be found in the development of different expectations of survival in the variety of environments accessed by human ancestors, and in the formulation of different predictions in the carrying capacity of certain landscape configurations for hunting. In general, landscape was of paramount importance in the process of biological fine-tuning of the responses to landscape features that could mean the life or death of the ancient forefather.

We inherited the entire set of results of millennia of decision making in the form of aesthetical conscience of what we like or dislike of the landscape (or of anything else, for that matter). When we take aesthetics into consideration, we are able to tap into the depths of that perceptual experience, which results in a unique measure of our psychological relationship with the external environment. In fact, aesthetics can be considered the direct outcome of an enormous set of instantaneous measurements of the external environment.

Along the same lines of thought, the participants of this study should be considered as measurers of the several landscape conditions. As discussed in the previous two Sections, the final experience of landscape significantly varied according to the dynamics of approach to landscape, and to the landscape being shown. In general, the patterned answers of the participants showed how any landscape is not perceptually isotropic in relation to the psychological variables being measured. Rather, it shows preferred modes of approach to elicit stronger reponses, and areas of approach where the *visual complexity* of the landscape is completely expressed by means of multiple occlusions, thus increasing the level of mystery. Instead, in other areas a strong topographical visual effect is not detectable because the observer is not in the corresponding observation "envelope" (or, "in the right place to observe").

This study shows that having a selective and specific access to landscape is feasible. Also, it is shown that by varying trajectory also the dynamics of such selective access is varied. Acknowledging this form of accessing landscape we can progress in several research directions, such as, for example, the mapping of visual accessibility spaces around landscape to classify how psychological response varies. We can also measure the degree of expression of *visual complexity*, and determine a preferred set of trajectories for a better visual resource exploitation. These new types of maps will be characterized by a projection of the visual accessibility spaces as a function of terrain form, since that resulted to be the determinant factor. The process of filtering in this case would be dedicated to rule-out the non-terrain-based possibilities of trajectory form.

The orientation of this study was fundamentally epistemological, that is, an investigation in the patterns of learning about and exploring landscape. Therefore, it might be opportune to conclude that while we can endlessly discuss about how to better visualize and represent landscape, more importantly the issue would be to guarantee to ourselves the access to accurate knowledge while exploring landscape. Our ancestors knew that such truthful concept of the environment was a convenient reference mark to guarantee themselves good chances of survival.

At the same time, we want to develop knowledge to represent planetary landscapes not to induce controlled (and thus, ethically questionable) emotions, but to instill interest in what already underpinned Flemish landscape painting five centuries ago: landscape that first can help us in represent our own reality (and desires) in an externalized format; and secondly, landscape as a placeholder, or a landmark, for a sense of mystery to be unfolded, able to stimulate the search for new accesses to what lies beyond.

Appendix A

A.1 Questionnaire

Landscape Appreciation

Administrator: Marco Ruocco

Circle a number from 1 to 7 to express your degree of agreement or disagreement with each of the following statements:

Likert Scale used in questions 1 - 13

1 2 3 4 5 6 7

| |

Strongly Agree Strongly Disagree

1) I liked the landscape shown in the animation.

2) The landscape shown in the animation seemed natural.

3) I liked the level of naturalness that I found in the landscape.

4) The landscape shown in the animation seemed closed.

5) I liked the level of closeness that I found in the landscape.

6) In general, the difference in elevation between high and low areas (e.g. between hills and plains) in the landscape seemed very high.

7) I liked the elevation differences present in the landscape.

8) The roughness of the landscape shown in the animation seemed very high.

9) I liked the level of roughness of the landscape.

10) I liked the vegetation cover of the landscape.

11) I liked the sky above the landscape.

12) I liked the water bodies present in the landscape.

13) I liked the way the helicopter flew around above the landscape.

Answer the following questions in the space provided:

14) What did you like about the landscape, if anything?

15) What did you dislike about the landscape, if anything?

16) What did you like about the way the helicopter flew around, if anything?

17) What did you dislike about the way the helicopter flew around, if anything?

Follow the instructions below, and write and draw in the spaces provided.

18) In the space provided below, draw a map of the landscape that you have been shown as if you were looking at it from above (i.e., a bird's eye view). Try to provide information about the topography of the landscape, indicating the location of features such as valleys, ridges, peaks, etc. Put verbal labels on the map to define the objects that you have drawn. Then, on the map, draw the line representing the trajectory of the helicopter on the landscape, as if you were looking at it from above.

19) In the space provided below, describe in your own words all the features you have drawn on your map.

20) In the space provided below, draw the line of the surface of the landscape flown over by the helicopter, from the start to the end of the animation, as if you were looking at it sideways from the ground (i.e., draw the profile view, or cross-section, of the landscape). Indicate variations in elevation such as those caused by valleys and ridges. Then, on top of that, draw the trajectory of the helicopter, as if you were looking at it sideways from the ground (i.e., draw the profile view of the trajectory of the helicopter), indicating variations, if any, in helicopter altitude during the animation. Remember to label both profiles.

START END

21) In the space provided below, describe in your own words all the features you have drawn on your map.

Circle a number from 1 to 7 to express your degree of agreement or disagreement with each of the following statements:

Likert Scale used in questions 22 - 47

1 2 3 4 5 6 7

| |

Strongly Agree Strongly Disagree

22) There were elements in the landscape that did not fit well with each other.

23) The landscape made sense to me overall.

24) There was too little variety in the landscape.

25) There were many things in the landscape.

26) It would have been easy to find my way around if I was walking on the ground.

27) I felt it would be better to find my way around if the helicopter flew closer to the ground.

28) I felt it would be better to find my way around if the helicopter flew higher above the ground.

29) The part of landscape I saw at the end of the animation was surprising.

30) During the animation I was curious about what I was going to see next in the landscape.

31) I felt the landscape was a pleasant place to be in.

32) I could easily see what was going on around me.

33) I felt sheltered by the surrounding landscape.

34) If I imagine people standing on the landscape and looking upwards, the helicopter would be very visible to them.

35) The landscape was unique.

36) The landscape had a specific character.

37) The landscape was easy to remember.

38) The scenery offered by the landscape was striking.

39) The way the helicopter flew around was exciting.

40) I would have liked to explore the landscape some more after the end of the animation.

41) I felt I could see a large enough portion of the landscape at any given time.

42) I felt myself present in the landscape.

43) I would like to know more about the landscape.

44) I feel there is not much more to see in the landscape beyond what was shown in the animation.

45) Any slight movement of the helicopter offered me a different view of the landscape.

46) The helicopter flew around too slowly.

47) The animation has shown a realistic landscape.

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