STEFFEN NIJHUIS

VISUAL RESEARCH IN LANDSCAPE ARCHITECTURE

"VISIBLE THINGS OFTEN APPEAR VERY DIFFERENT FROM WHAT THEY REALLY ARE."
Johann Heinrich Lambert (1752)

5.1 INTRODUCTION

The core of landscape architecture as a design discipline is the construction and articulation of three-dimensional outdoor space. It considers the *representation*, *realisation* and *apprehension* of the three-dimensional composition as constituent components of spatial design. This architectural way of space-making is a living and constantly changing power, influenced by the philosophical, religious and scientific attitudes in the societal context (Bacon, 1967).

Representation is essential in the understanding and construction of space [1], not only for visual thinking and visual communication in the design process, but also as it addresses the dialogue between the *conceptual* and *perceptual* order of space. It expresses the fundamental difference between the physical, metric reality (Euclidian space) and its visual appearance (perceived space). A representation can portray an already existing spatial reality, but can also be a projection of an imaginary three-dimensional concept. As Bacon (1967) suggested: "these two phases interact with each other, the concept influencing the structure and the structure influencing the concept in a never-ending interplay… The designer conceives a three-dimensional form which is later [constructed]. From observation of [the actual constructed space] the designer gains new understanding…" In other words: the designer acquires a new understanding by examining the physiognomy or visible form of the composition, which is linked with movement of the observer through the space, and then can implement it in another context. Thus we can

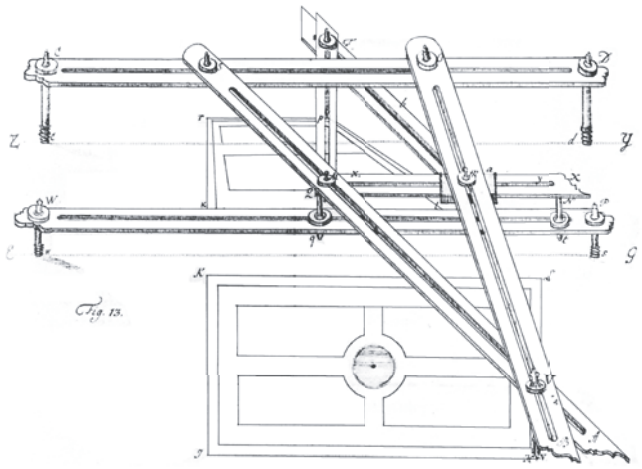


Figure 1
18th century perspectograph (distorting pantograph), a device that could apparently transfer an orthographic plan of garden into a perspective representation. From Anlage zur Perspektive (1752) by Johann Heinrich Lambert (source: Pérez-Gómez and Pelletier, 1997)

consider the visible form and its representation as the interface between the conceptual and perceptual space, and as a container of object-related and typological design knowledge.

Since the early beginnings of design disciplines practitioners and researchers have been involved in discovery and development of instruments to map (represent and apprehend) architectonic space (see figure 1). This quest still continues, now influenced by computational and technical advances in, for instance, Geographic Information Science (GISc).

5.1.1 Landscape architecture, space making and GISc

In landscape architecture the dialogue between the conceptual and perceptual space is often subject of intuitive and experimental design, taking into account physiological, psychological, and anthropometric aspects. However, when we consider landscape architecture as a scientific discipline as well as a profession, knowledge-based design becomes an important issue, as put forward by Steenbergen et al. (2002, 2008), De Jong and Van der Voordt (2002) and Klaasen (2004). In knowledge-based design a methodical approach is required were understanding of space by means of analysis is the prerequisite for the formulation of new designs (Steenbergen et al., 2008; Nijhuis, 2010).

Early essays on landscape architectonic design, like Repton (1803), Andre (1879) and Hubbard and Kimbal (1935), offer valuable design knowledge by presenting principles of three-dimensional space construction based on practical experience and experimentation. GISc offers

designers new possibilities for mapping landscape architectonic compositions to deepen and broaden the body of knowledge about the understanding of the relation between the conceptual and perceptual space. Although this relationship is complex in nature (e.g. it's involvement of subjective aspects of perception) it is worthwhile to consider the concepts and tools of GISc for analysing the 'horizontal perspective' (as an observer exploring the visual space), which have a great potential for this kind of design research.

5.1.2 Aims and structure

This chapter aims to explore some basic concepts of the horizontal perspective linked to landscape architectonic design research by means of Geographic Information Systems (GIS). It is about the analysis of the visible form and its architectonic composition as would be experienced by an observer moving through a virtual space, by making use of GIS-based isovists and viewsheds. On one hand it introduces the basic concepts of visual perception and the role of movement. On the other, it explores how some of these concepts can be revealed by using GIS, presenting particularities of the perceived landscape architectonic space.

The chapter is structured as follows: Firstly, landscape architecture is positioned as a design discipline focussed on the study of three-dimensional compositions, following that a framework for design research is introduced in section 5.2. Secondly, the concept of visible form is elaborated involving the basic concepts of visual perception and movement in section 5.3. Thirdly, the potential of GIS in visibility analysis for grasping the visual form and it's architectonic composition is exemplified by two examples: *Piazza San Marco* (Venice, Italy), as a designed space of buildings, and Stourhead landscape garden (Wiltshire, UK), as a designed space of vegetation and relief in section 5.4. Isovist and viewshed functions in particular are explored. The chapter ends with concluding remarks and discussion.

5.2 LANDSCAPE ARCHITECTURE: DESIGNING OUTDOOR SPACE

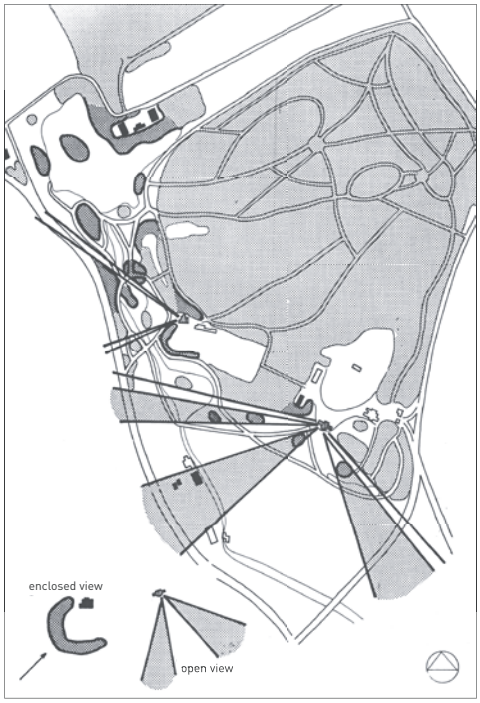
According to the Encyclopedic Dictionary of Landscape and Urban planning (Evert et al., 2010) landscape architecture is "a profession and academic discipline that employs principles of art and the physical and social sciences to the processes of environmental planning, design and conservation, which serve to ensure the long-lasting improvement, sustainability and harmony of natural and cultural systems or landscape parts thereof, as well as the design of outdoor spaces with consideration of their aesthetic, functional and ecological aspects." However, the practice of landscape architecture [2], the arrangement of landscape as manifestation of spaces

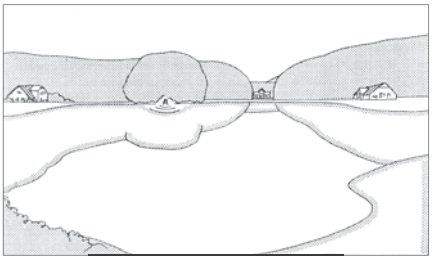
and objects, is as old as human existence (Pregill and Volkman, 1999; Rogers, 2001; Newton, 1971). Within the broad field of landscape architecture there are three areas of activity according to the scales of time and space in which they operate: *landscape planning*, *landscape design* and *landscape management*. See Stiles (1994a, 1994b) and Thompson (1999) for an elaboration on this topic. This chapter focuses upon landscape design, in particular the design of sites.

5.2.1 Research, design and three-dimensional space

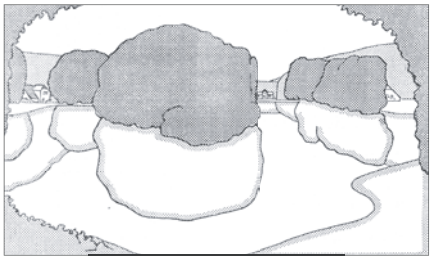
Landscape architecture consists of a basic attitude that involves four principles of study and practice. These are: *anamnesis (palimpsest)*, *process*, *three-dimensional space* and *scale-continuum (relational context)* (Nijhuis, 2006; Prominski, 2004; Marot, 1995). This chapter is about three-dimensional space as a crucial aspect in landscape design and comprises of the representation, realisation and apprehension of outdoor space. In the Dutch landscape architecture tradition, especially design research, we find clues to grasp three-dimensional space in landscape

Figure 2
Visual analysis of the parks of Sonsbeek, Zijpendaal en Gulden Bodem in Arnhem (the Netherlands) representing views and their compositions (source: Warnau, 1979)





view



view with scenic intricacy that arouses and sustains curiosity

		OBJECT	
		determined	**variable**
CONTEXT	**determined**	plan analysis	design experiment
	variable	comparative research	experimental design
		design research	*research by design*

Table 1
Design research and research by design: a variable relationship between object and context (source: Steenbergen et al., 2008)

design, exemplified by the seminal works such as: Architecture and Landscape (Steenbergen and Reh, 2003), Designing Parks (Baljon, 1992), *Rapport over de parken Sonsbeek, Zijpendaal en Gulden Bodem in Arnhem* (Report about the parks Sonsbeek, Zijpendaal and Gulden Bodem in Arnhem) (Warnau, 1979) and *Waarnemen en ontwerpen in tuin en landschap* (Perception and design of garden and landscape) (Bijhouwer, 1954) (see figure 2). In these studies landscape design is considered as a three-dimensional composition of natural, cultural, urban and architectonic elements related to aesthetic, ecologic, social and economic parameters.

Landscape design in relation to spatial compositions involves two important research domains: *design research* (analysis of existing designs or precedents) and *research by design* (formulation of new designs) (De Jong and Van der Voordt, 2002). These respective research domains and their variables are positioned in table 1. The two components cannot be seen apart from each other: design research is an indispensable step in research by design. From this point of view we can consider this approach as a form of heuristics (way to find), a scientific approach that leads to new discoveries and inventions by taking a methodical approach (Steenbergen et al., 2002).

Especially in the work of Steenbergen *cum suis* (2009, 2008, 2003) we find a well-established framework for (typo)morphological research related to landscape as an architectonic composition (see figure 3). Here the composition is understood as the vehicle that establishes the relationship between content and form. Content is everything that comprises the landscape architectonic object, its material, topography, technical structure, and cultural substance. The form involves the way in which the parts are assembled in a composition and is considered as the interface between intention and perception (Steenbergen et al., 2008).

Figure 3
Landscape as a composition. There are endless possibilities to arrange the landscape in a harmonious, good composition. The procedure, however, influences the quality of the result as illustrated by this 19th century game: 'Myriorama' or 'Endless Landscape' (Leipzig, 1830). When all 24 cards are laid side by side there are millions of combinations possible

5.2.2 Design research and visible form

Design research related to three-dimensional landscape compositions is about analysis of existing designs or precedents in order to acquire typological knowledge and designerly insights that can be used in the creation of a new design. Examining the architectonic composition is crucial here, because it is the container of design knowledge. This knowledge derived from the composition can extend beyond the intention of the designer; the plan analyst can reveal more insights than the designer consciously put in the design. It is possible to explore and to identify more than the designer's immediate goals. The researcher's interpretation can therefore be of equal value for the meaning of the design as the for designer's intention (Baljon, 1992; Mooij, 1981).

An architectonic composition can be comprehended by addressing the most general concepts that lay out the relation between the various aspects of the architectonic form and its perception in a systematic way (Steenbergen and Reh, 2003). Frankl (1968) defined four important layers of interest:

- *Basic form:* the way in which the topography of the natural landscape or the man-made landscape is reduced, rationalised and activated in the ground plan of the design;
- *Corporeal form:* three-dimensional (space defining) forms made by spatial patterns composed of open spaces, surfaces, screens and volumes in the landscape (Euclidian space);
- *Visible form:* appearance of the landscape (perceived space). It is about the perceptual space addressing the sensorial experience that emerge only by movement and is affected by atmospheric conditions;
- *Purposive intention:* relationship of the landscape architectonic object to the social institutions for which they are conceived. The (functional) zoning and organisation of the programme in relation to the configuration movement is usually an important expression of this.

These layers of interest for the description and analysis of architectonic compositions are partly adopted and elaborated for landscape architecture by Steenbergen et al. (2003, 2008), with emphasis on the rational analysis of a landscape architectonic composition (i.e. basic form, spatial form, metaphorical form and programmatic form) and the development of an effective way of representing them (see for examples e.g. Steenbergen et al., 2003, 2008, 2009). With regards to three-dimensional space the emphasis of this framework is on the conceptual space; the metric reality of a three-dimensional composition presented by its spatial form. However, Frankl (1968) emphasises that the design also consists of a perceptual space, it's visual reality, addressing the sensorial experience that emerges only by movement and is affected by atmospheric conditions. As opposed to *corporeal form* he suggested *visible form* as an important aspect of a design's three-dimensional composition. This visible form derives from the act of perceiving (especially seeing), which is linked with the sequential unfolding of information as our bodies pass through space (Frankl, 1968; Psarra, 2009).

5.3 VISIBLE FORM IN LANDSCAPE ARCHITECTURE

Visible form in landscape architecture is about the visual manifestation of three-dimensional forms and their relationship in outdoor space, expressed by its structural organisation (e.g. balance, tension, rhythm, proportion, scale) and ordering principles (e.g. axis, symmetry, hierarchy, datum, transformation) (Bell, 1993; Hubbard and Kimball, 1935). It refers to the appearance of objects; it is about the 'face' of the spatial composition. However, the meaning attached to it is referred to as semantic information, and is dependent on the receiver (Haken

and Portugali, 2003; Blake and Sekuler, 2006). Thus there is a subjective part containing symbolic, cultural and personal elements which finally determine the experience of landscape architectonic space (see e.g. Kaplan and Kaplan, 1989).

How can we understand visible form in order to extract design knowledge? According to Salingaros (2005) "we define our living space by connecting to solid boundaries, visually and acoustically as well as through physical contact. Strictly speaking, outdoor space doesn't need [e.g.] buildings at all; only surrounding surfaces, nodes for sitting and standing, and paths". In short, we define our environment as a collection of surfaces, screens and objects in space. So landscape architectonic composition consists of a given spatial relationship between these considering the diurnal and seasonal variations in natural light. The visible attributes of the space-establishing elements are position, size, direction, number, shape, colour and texture which every visible form posses under any condition of illumination (Thiel, 1961; Gibson, 1986; Bell, 1993; Simonds, 1997).

The observer's relationship to these visual descriptors is of a higher geometrical order and they locate their position by using a rough polar or vector orientation in terms of distance and direction (Gibson, 1986). This optical structure is called an *ambient optic array* and was introduced by Gibson (1961). He explained the optic array as a set of nested solid angles corresponding to surface elements in the environment. The architectonic space exchanges information via these fields with our senses; it is a visual information field (Gibson, 1986; Salingaros, 2005).

5.3.1 Perceiving visible form

Although physical space is three-dimensional, these dimensions are not equal to human perception of space. The cognitive organism acts on visual information that is imaged on the retina. In other words: the perceptual space is flattened in terms of information content (Blake and Sekuler, 2006; Snowden et al., 2006; Ware, 2008). Thus visual space has dimensions that are very different from the geographic or measured space and each dimension has different affordances. This perceptual space consists of an *up-down* and *left-right (sideways) dimension* (the *retinal image* or *picture plane*) and a *distance dimension* (*depth*) (Blake and Sekuler, 2006; Ware, 2008). These different characteristics are of greatest importance for landscape design because they not only determine if and how the visual form is perceived, but also can be consciously applied to achieve a certain spatial quality and establish space relationships.

The information from the up-down and sideways dimension is basically a matter of visual pattern processing and colour discrimination and is the basis for recognition of objects and their relationships. Pattern recognition is primarily about *contours (shape), regions, spatial grouping*

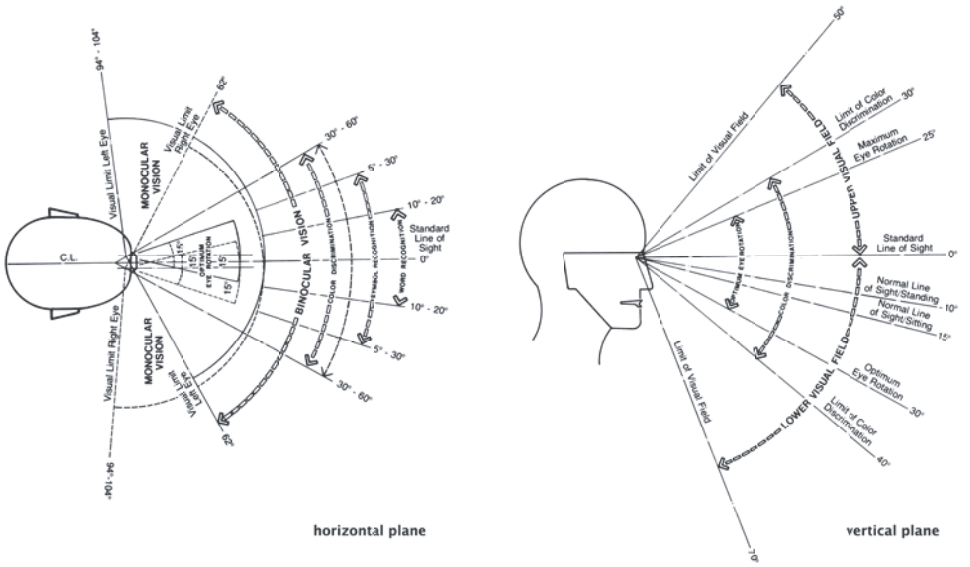


Figure 4
Field of vision in the horizontal and vertical plane (source: Panero and Zelnik, 1979)

(based on: nearness, continuity, similarity, enclosure, shape and common direction) and *visual distinctness*. Visual distinctness describes the degree of feature-level contrast between the object and its surroundings (e.g. figure-background) (Blake and Sekuler, 2006; Ware, 2008; Bell, 1999, 1993). *Field of vision* (*syn.:* field of view) is crucial in this respect because it determines the visibility and perception of the visible form in the picture plane. Humans have an almost 120 degrees forward-facing horizontal, binocular field of vision. Within this field sharp images are transmitted to the brain, depth perception and colour discrimination is possible. However, the ability to perceive shape (pattern recognition), motion and colour vary across the field of view (see figure 4). Pattern recognition concentrates in the centre of the field of vision and covers about 20-60 degrees binocular view (Panero and Zelnik, 1979; Snowden et al. 2006). However, the highest degree of acuity we find in the range of about 20-30 degrees binocular view. This is due to the much higher concentration of cone cells (type of photoreceptors) in the fovea, the central region of the retina, which corresponds with a visual angle of 12-15 degrees per eye (= ca. 20-30 degrees binocular view), from there the acuity of the eye rapidly falls off (Snowden et al., 2006; Ware, 2004). This physiological fact determines the size and measurement of perceivable views and objects in landscape architectonic compositions, as we will discuss later.

The information from the distance dimension is about perception of depth. Depth cues consist of spatial information that is used to evaluate distances from the observer's point of view and can only be obtained by movement of the eye, head and body. In other words *we can only expe-*

rience space by movement (Blake and Sekuler, 2006; Ware, 2008; Bell, 1999). Depth cues can be divided in physiologic, kinetic and pictorial cues. Pictorial depth cues can be reproduced in a painting or a photograph, or consciously applied in landscape architectonic design. The most powerful depth cue is *occlusion* (objects that visually block other objects appear closer). Other depth cues are related to the geometry of perspective: *linear perspective, size gradients* and *texture gradients*. Furthermore, *cast shadows, height on picture plane, shading*, *depth of focus, size relative to known objects*, and *atmospheric contrast reduction* are important depth cues (Blake and Sekuler, 2006; Snowden et al., 2006; Ware, 2008). Each of the depth cues support different kinds of visual queries and can be applied (individually) in a landscape architectonic composition to create optical illusions or pictorial effects. Non-pictorial depth cues are related to the physiology of the visual system: *stereoscopic depth (stereopsis), accommodation* and *convergence*, and kinetics: *structure from motion (motion parallax)* (Blake and Sekuler, 2006; Snowden et al., 2006; Ware, 2008).

5.3.2 Movement and landscape architectonic composition

We can only experience landscape architectonic space by movement. As opposed to a painting, we move through a landscape or a building and its visible form alters or changes constantly, as does its internal relationships. The interpretation of every single image as three-dimensional that we receive from different viewpoints are (usually) not ends in themselves but part of a series of three-dimensional images which draw together the architectonic image (mental image) of the composition (Frankl, 1968) [3]. This kinetic experience of the observer who arrives at a 'single' image as the product of many partial images is summarised by Hoogstad (1990) as: *Space = Time (+ memory) x Movement*. In other words, visible form is about the construction of time-space relationships among the space establishing elements and their attributes (Hoogstad, 1990). Successive acts of perception and recognition influences one's sense of time. Observers in motion perceive change successively and adjust their knowledge. For instance, individuals tell the length of their walks by the rhythmic spacing of recurring elements. The more spatial variation, the shorter the walk appears; but recalling from memory, the walk appears longer (Bosselman, 1998).

Landscape architectonic compositions stimulate, or at least permit, certain kinds of movement with different modalities, and manage speed and direction. So movement takes place partly in response to or in accordance with the designer's intentions (Conan, 2003; Hunt, 2004). Yet together with spaces, paths are considered to be paramount structural components of (designed) landscapes because they play a crucial role in mediating or facilitating the experience and use of these compositions (Dee, 2001; Bell, 1993). In this respect paths and routes play a crucial role as structural organisers of the architectonic image (Appleyard, 1970; Lynch, 1960).

Related to movement through space we can distinguish three modes of vision:

- *Stationary vision:* standing still or sitting; frontal perception of a fixed scene;
- *Slow-motion vision:* walking, cycling and horse riding; slow sequential frontal and/or lateral perception of scenes;
- *Fast-motion vision:* car driving, motorcycling and train; fast sequential frontal and/or lateral perception of scenes.

The characteristics of these modes of vision have wide ranging implications for the visible form. For instance, the speed of movement determines the visual angle and the focus towards the landscape (e.g. with increasing speed the visual angle narrows down). This chapter focuses on stationary vision and slow-motion vision because it closely relates to the primordial act of walking as an aesthetic and social practice (Careri, 2002; König, 1996; Solnit, 2001) [4]. The relevance of this for landscape architecture is put forward by Conan (2003), Hunt (2004) and De Jong (2007). The latter summarises it as follows: "the walk [(as an action, but also a route)] represents an important unifying and structural principle in the design of garden and landscape architecture and the discovery of landscape from past to present. It must be considered the hinge that steered more than anything else the changing options for use, experience, and design and contributed fundamentally to both personal and cultural developments" (De Jong, 2007).

5.3.3 Visually controlled movement

With regard to visible form it is important to link visually controlled movement to space perception. Perception of space is essentially about perception of action potential within the local environment. This concept is referred to as *affordances* (Gibson, 1986). Gibson (1986) conceived affordances as physical properties of the environment, which are about linking perception and action. So, paths afford walking, a bench affords sitting, et cetera. Affordances in visual space are readily perceived possibilities for action, especially movement. With regard to the visual form we can speak of *visually controlled movement*. An open environment affords movement in any direction, and an environment with surfaces, screens and objects only at openings (Gibson, 1986). Research in *wayfinding* [5] indicates that route choice behaviour is for 60% depended on spatial aspects such as space perception, spatio-visual attractiveness, arousal and orientation (Korthals Altes and Steffen, 1988). So the visible form is crucial because it affords movement by its openings, offers a sense of direction by its spatial orientation and offers arousal/attraction by its visual composition.

Visual *anchor points* are another important factor in the spatial composition and function as orientation points or 'attractors', and induce and direct movement (Golledge and Spector,

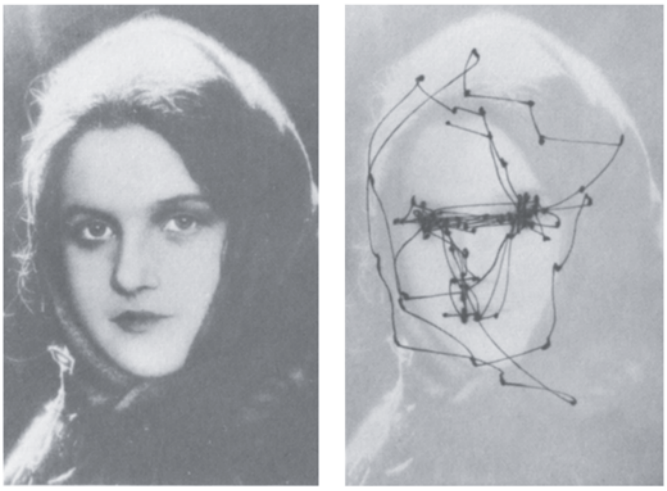


Figure 5
Record of eye movement during free examination of a photographed face. The eye fixates mainly on the eyes and mouth as anchor points in the 'landscape of the face' because they provide important information on the internal state of mind of the person on the picture and are the basis for action (source: Yarbus, 1967)

1978; Golledge, 1999; Hillier et al., 1993). Anchor points are key primitive elements or strategic foci (significant features or landmarks) in space and attract our attention more than other areas of the landscapes' face. Yarbus (1967) pointed out that they provide more information than others and carry useful or necessary information for recognition and understanding of spatial relationships and function as 'spatial magnets' or destinations (see figure 5). In this respect we can distinguish three different means for movement: travel to familiar destinations, exploratory travel and travel to novel destinations (Allen, 1999). In these types of movement *following a marked trail* and *landmark-based piloting* are important modes of wayfinding, which have their applications in landscape design, as we shall see later. Landmark-based piloting refers to the act in which the observer relies on sequentially organised knowledge: a landmark is associated with direction and distance information that leads to another (Allen, 1999). It can be considered as a landscape architecture tool for initiating movement.

5.3.4 The shape of a walk: organising visual logic

As we have seen the visible form of a landscape architectonic composition derives from the act of visual perception, which is linked with the sequential unfolding of visual information by movement through space. Paths do not only provide passage but also direct movement through the three-dimensional composition. In addition, paths offer a means to organise the visual

logic of a site by directing the visitor's gaze at (distant) views or focal points (e.g. buildings, objects) and their sequence (serial vision) as a spatial narrative (O'Malley et al., 2010; Psarra, 2009; Potteiger, 1998). Focal points serve often as 'destinations' and induce movement (i.e. landmark-based piloting).

Hunt (2003, 2004) proposed a taxonomy of 'walkscapes' in designed landscapes, which exemplify the intended relation between movement and visible form:

- *Procession:* ritual movement that follows both a preordained path and purpose and is determined by implicit or explicit guidelines constituting the performance of that ritual laid down in formal records such as social or religious conventions or written text (examples: Sacro Monti, Varallo (Italy), and Versailles, Paris (France));
- *Stroll:* movement with an ultimate purpose within the site and a sense of destination. Strolling also implies a defined route between whatever incidents punctuate and give rhythm to the movement (examples: Stowe landscape gardens, Buckinghamshire (England), and California Scenario, Costa Mesa, California (USA));
- *Ramble:* movement without an external prompt, they are promoted largely by the will or curiosity of an individual. Rambles are for the pleasure of movement itself (examples: Central Park, New York (USA), and Vondelpark, Amsterdam (the Netherlands)).

As such the landscape architectonic composition is visible by stationary vision and slow-motion vision, and is choreographed by the configuration of paths. In this way we can consider a landscape architectonic design as a three-dimensional composition of scenes, views and tableaux with references, symbols and stories (Vroom, 2006; Olwig, 2002). This presumes that 'pictorialisation' [6] or *scenography* (stage setting) and its sequence are significant aspects of the visual organisation and perception of landscape architectonic compositions (Grandell, 1993). Furthermore, the individual surfaces, screens and objects within the composition can have a certain spatiality or visual effect such as *spatial radiance* which bestow a certain visual direction and amplitude (Arnheim, 1977; Von Meiss, 2004).

5.3.5 The scene as a image

The formal relationship of three-dimensional objects in space is visible as a *scene* (*tafereel*) on the retina (Hoogstad, 1990). A scene refers to an extensive piece of the (urban) landscape that can be seen from a single (or multiple) point of view as in a painting or as a stage of a theatre [7] with a foreground, middle ground and background (O'Malley et al., 2010; Repton, 1803). More particularly, it is about *views*, *feature views* or *focal views (vistas)*, which are (composed) landscape unities within the horizontal, binocular field of vision of about 20-30 degrees (Hubbard and Kimball, 1935). This corresponds with the centre of our field of vision, as discussed before,

and it appears that this anthropometric fact is a decisive factor in spatial design. Research of Pechère (2002) pointed out that 22 degrees is a common used angle to determine appropriate views in landscape design, and Schubert (1965) discovered the sequence of 20, 30, 33 and 42 degrees in urban design with the emphasis on 20 and 30 degrees for important ensembles [8]. View-making involves demarcating, organising and framing of scenes with architectonic objects (e.g. by using buildings, porches and porticos), planting and barriers such as walls, fences and hedges. These barriers are used to direct the gaze by openings in them or screen less 'picturesque' elements.

Through the centuries the principles of view-making in relation to movement is a constant factor, while the context of landscape architectonic composition itself varied (Grandell, 1993). Steenbergen and Reh (2003) distinguished three important contexts: *rational*, *formal* and *pictorial*. For example: whereas the French formal garden was based on a single axial view from the house, the English picturesque garden was a series of multiple oblique views that were meant to be experienced while one walked through it. Through the ages "the [landscape architectonic] composition was becoming more cinematic than pictorial; it was designed to be experienced in motion as a series of compositions dissolving into each other rather then as a picture…" (Solnit, 2001). The sequential experience of 'moving pictures' also became the basis for film and cinema as beautifully illustrated by the rolled-up panoramic landscapes on translucent paper by Carmontelle, an eighteenth-century French painter and landscape designer (De Brancion, 2008).

Independent of the different contexts, views were carefully planned combining formal, transitional and progressive elements. Views were also often subject to optical illusions making use of depth perception (especially pictorial depth cues) and size constancy. By manipulating the spatial dimensions and layout landscape architects created the illusion of distance (impression of greater depth) as, for instance, brilliantly elaborated at Vaux-le-Vicomte, Melun (France) (Steenbergen and Reh, 2003; Hazlehurst, 1980). Views were not only valued as aesthetically pleasing, but were also equated with ownership and control of one's domain (O'Malley et al., 2010).

5.4 MAPPING VISIBLE FORM WITH GEOGRAPHIC INFORMATION SYSTEMS (GIS)

As discussed before the visible form is the interface between the intention and the perception of the landscape architectonic design. Therefore it is important to acquire object-related and typological design knowledge on the perceptual order of landscape architectonic compositions. This addresses the question of how a design interfaces the conceptual order (physical space)

with the perceptual order (visual space). GISc in relation to the perceptual order considers architectonic compositions as visibility fields and explores those parameters that are observable by a viewer located within space (the horizontal perspective), and those configuration properties that can be discovered by visual experience evoked by optical axes, visibility fields and sequences of visual information (Psarra, 2009; Tzortzi, 2004). It incorporates the related concepts of visual perception with regards to the organisation of visual logic, space-making, composing views and the control of movement.

Tandy suggested already in 1967 the application of isovists or viewsheds ("limit-of-vision plottings" and "visual watersheds" as he called them) in order to "convey the spatial composition from an observers point of view" and "to enable visual analysis of the landscape" (Tandy, 1967). Later, Benedikt connected Gibson's concept of the ambient optic array to isovists and isovist fields for means of architectonic research (Benedikt, 1979, 1981). For landscape planning, the concept of viewsheds is elaborated by Higuchi and Lynch for means of visual impact analysis (Higuchi, 1975; Lynch, 1976).

Due to advances in computer science the concepts of visibility-analysis are nowadays a widespread phenomena with a broad palette of applications (for examples see other contributions in this book). More particularly, advances in GISc offer researchers in (urban) landscape design interesting clues to engage in the field of visual research. GIS-based concepts of *isovists* (sight field polygons) (see e.g. Rana, 2002; Batty, 2001) and *viewsheds* (see e.g. Llobera, 2003; Fisher 1995) can especially help to comprehend the relation between the conceptual and perceptual space and offer different modes of representation. The typical difference between the two concepts is that the raster-based viewsheds represent parts of space that are visible, taking into account vertical viewing angle and elevation, while vector-based isovists consider visible space in the horizontal plane. The result is a closed polygon that can be characterised with different numerical parameters (Batty, 2001; Turner et al., 2001).

Although both concepts have great potential for landscape architectonic research we only see them sparsely applied in the field of landscape design. However, for means of visual impact analysis and landscape character assessment we see several applications of the GIS-based viewshed in landscape planning (see e.g. chapters 10, 11, 12, 13), and only recently the use of GIS-based isovists (Weitkamp, 2010; see chapter 9).

5.4.1 Research approach towards examples

The aim of this section is to describe, map and analyse the visible form made by spatial patterns composed of open spaces, surfaces, screens and volumes as it could be experienced by

an observer moving through a virtual space, making use of GIS-based isovists and viewsheds. It addresses the physiognomy of space with visibility as a key element. The potential of 'being able to see' is mapped out and addresses plausible and/or probable visible space (Fisher, 1995, 1996; Weitkamp, 2010).

This section explores the use of viewsheds and isovists in landscape design research in order to reveal some important visual concepts by using two examples which are well-documented architectonic objects and offer widely acknowledged designed spatial qualities which have the potential to be tested and verified by means of GIS. It offers an actual (non- or a-historical) and formal reading of the sites. The analysis of visual form reveals the perceived spatial potential as a basis for performance and reception. The *Piazza San Marco* (Venice, Italy), famous for its space relationships and articulation of space, is used as an example for the analysis of a designed space of buildings. Stourhead landscape garden (Wiltshire, UK), famous for its pictorial circuit with composed views in a sequence, is used as an example for the analysis of a designed space mainly of vegetation and relief. The first example focuses on the application of isovists analysing the entrance of the square and the spatio-visual impact of the bell-tower using sequences of viewpoints and a field of viewpoints. The latter is about application of viewsheds for means of analysing composed views and their sequence by using multiple single viewpoints and their sequential/specific organisation.

The examples are based on highly accurate digital and digitised data obtained from field surveys provided respectively by the University of Venice (*Piazza San Marco*) and The National Trust (Stourhead) complemented or corrected by other sources (archival material, historical maps, map reconstructions, etc.) and field observations. For testing the results of the measurements we used text interpretation (expert-judgement), digital three-dimensional models, (aerial) photographs and measurements in the field.

5.4.2 Space relationships and articulation of space: Piazza San Marco, Venice (Italy)

The *Piazza San Marco* is one of the quintessential parts of Venice and is highly appreciated by inhabitants as well as thousands of tourists. The square is a symbol that represents the city of Venice, its history, politics, religion and social and ethical values. The vicissitudes of the piazza's transformation are slow and far-reaching and have occurred over a long period of time (see e.g. Samonà et al., 1970; Morresi, 1999; Schulz, 1991). The piazza is divided into two parts that form an L-shape: the actual piazza and the *piazzetta* (little square). The L-shape is one of the most challenging designs for a square, and the least liable to succeed. This shape has a distinct disadvantage as each branch, the piazza and the piazzetta, has a hidden counterpart (see figures 6 and 7). Nevertheless, the architectonic composition is very successful and is

Figure 6
Piazza San Marco

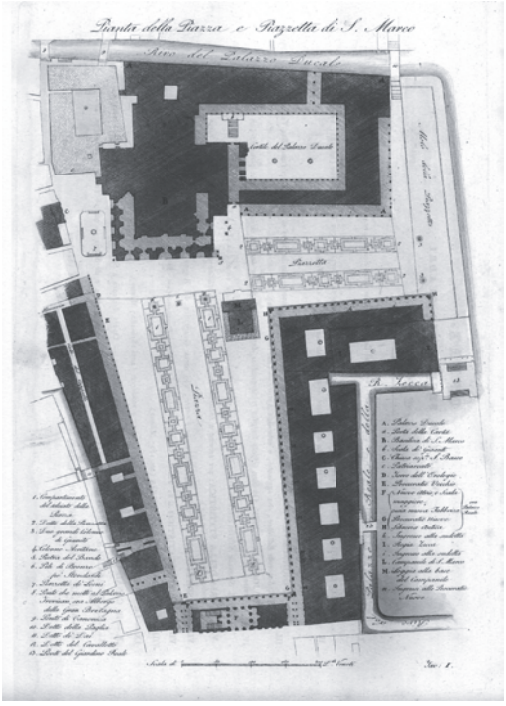


Figure 7
Plan of the Piazza San Marco. Dionisio Moretti, 1828
(source: Supernova Edizioni)

acknowledged for its spatial qualities such as the articulation of space and space relationships (see e.g. Janson and Bürklin, 2002; Newton, 1971; Samonà, 1970). In this example we focus on space relationships and the articulation of space.

Origins of the square

A group of marsh islands or mudflats (called: *Barena*) in the Venetian Lagoon, formed some 6000 years ago, was a precondition for settlement starting in the 5th century. Venice begun to emerge as an early archipelago in the 9th century (Ammerman, 2003; Crouzet-Pavan, 2002; Bellavitis and Romanelli, 1985). However, the occupation of the islands at San Marco dates from the 7th and 8th century (Ammerman et al., 1995). The actual *Piazza San Marco* had its beginning in 811, when the ducal seat was moved from Malamocco (Lido) to Venice. With the construction of the ducal palace and then the Basilica of San Marco, the doge's private chapel, the area at the head of the Grand Canal became the hub of political and ceremonial life in the city, and the Venetian Republic (Schulz, 1991; Fenlon, 2009, 2007).

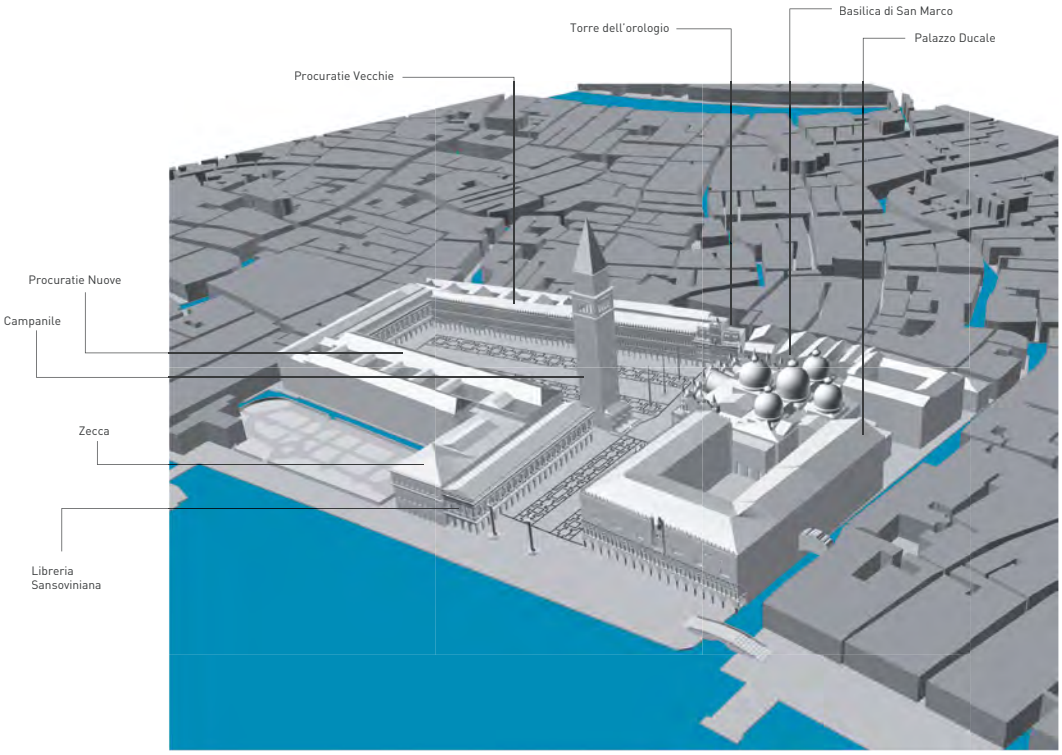
Figure 8
The location of the Piazza on a map of the 8th and 9th century Venetian settlements (source: Trincanato and Franzoi, 1971)

The site consisted originally of two islands, which by land reclamation and architectonic endeavours transformed radically from the 1160s (or 1170s) onwards (Schulz, 1991) (see figure 8). The shape of the square we know now dates from the mid 15th century as a result of an ambitious *renovatio urbis* led by the state architect Pietro Bon († 1529), later succeeded by Jacopo Sansovino (1486-1570). It remained the centre of the city-state until the fall of the Venetian Republic to Napoleon in 1797. He called the *Piazza San Marco* "the finest drawing-room in Europe" because of its architectonic qualities (Fenlon, 2009; Goy, 1997).

Architectonic system of the square

In terms of geometry the piazza is the predominant part of the ensemble, with the *Basilica di San Marco* as the terminal focus of attention. The piazza is a trapezoidal form of 175 metres long and 81 metres wide at the campanile (bell tower), and 56 metres wide in front of the *Palazzo Reale*. The view towards the façade of the basilica is framed by the space defining facades of the *Procuratie Vecchie* and *Procuratie Nuove*, and the foot of the campanile. The whole

Figure 9
Three-dimensional model of the square (by S. Nijhuis and J. Wiers)



façade of the basilica is seen at glance because the determined view covers a visual angle of 20 - 33 degrees (Schubert, 1965), which corresponds with centre of the binocular field of vision. This view is also subject to optical illusions making use of pictorial depth cues, like the diverging lines of the surrounding facades 'slowing down' the optical perspective and shrinking the optical size of the basilica. In the reverse direction the length of the square is exaggerated by the converging lines, 'speeding up' the optical perspective.

The southern branch of the L-shape, the piazzetta, is 96 metres long and its width varies from a minimum of 40 metres (south-end) to a maximum of 48 metres. The piazzetta is formed by the *Palazzo Ducale di Venezia* and the *Libreria Sansoviniana*, which converge slightly at the south-end. Here two freestanding columns frame the sunlit view across the water to *San Giorgio Maggiore* (by Andrea Palladio; 1508-1580), the island church seemingly 'floating on the lagoon'. Also here the organisation and demarcation of the view is based on the field of vision of 20-30 degrees (Schubert, 1965). By pushing the *Libreria* (and *Zecca* (mint)) southward to the lagoon, the building mass gives direction and orientation to space and movement from the *Molo* (water-side) 'pointing' towards the piazzetta and piazza. In the piazzetta, the entrance of the campanile visually points towards the main-entrance of the palazzo.

The campanile acts as pivotal point or hinge on which the two spaces turn; the relatively greater height of the tower, compared to the *Libreria* and *Procuratie Nuove*, undoubtedly enhances its space-turning role (Janson and Bürklin, 2002; Newton, 1971; Von Meiss, 1991). The tower as occluding element gives the piazza and the piazzetta relative autonomy, yet at the same time they announce each other's presence (see figure 10). The position of the bell-tower provides for a constantly change in scenery (shifting of scenery or changing visibility at eye-level), as we will elaborate later. The space turning role of the tower is supplemented by an implicit boundary (by three bronze pedestals), denoting the small space immediately in front of the basilica. This space is shared by the piazza and the piazzetta and interlocks the two squares as a spatial unity. The continuous colonnade optically connects the squares "like broad ribbons of space with a feeling of continuity around the bend" (Newton, 1971).

As it is a square, the experience of visible form is not directed by paths or routes, but by the entrances to the square and the visual effect of the architecture and space relationships. In this respect the landscape architectonic composition affords movement by its openings, offers a sense of direction by its spatial orientation and offers arousal/attraction by its visual composition.

Mapping the perceptual order: entrance and hinge-effect

As previously discussed, space relationships and visual effect are decisive in the architectonic system of the square. More over, the entrances to the square and the hinge-effect of the campanile are crucial aspects of the visible form. In order to map the visible form of the piazza by

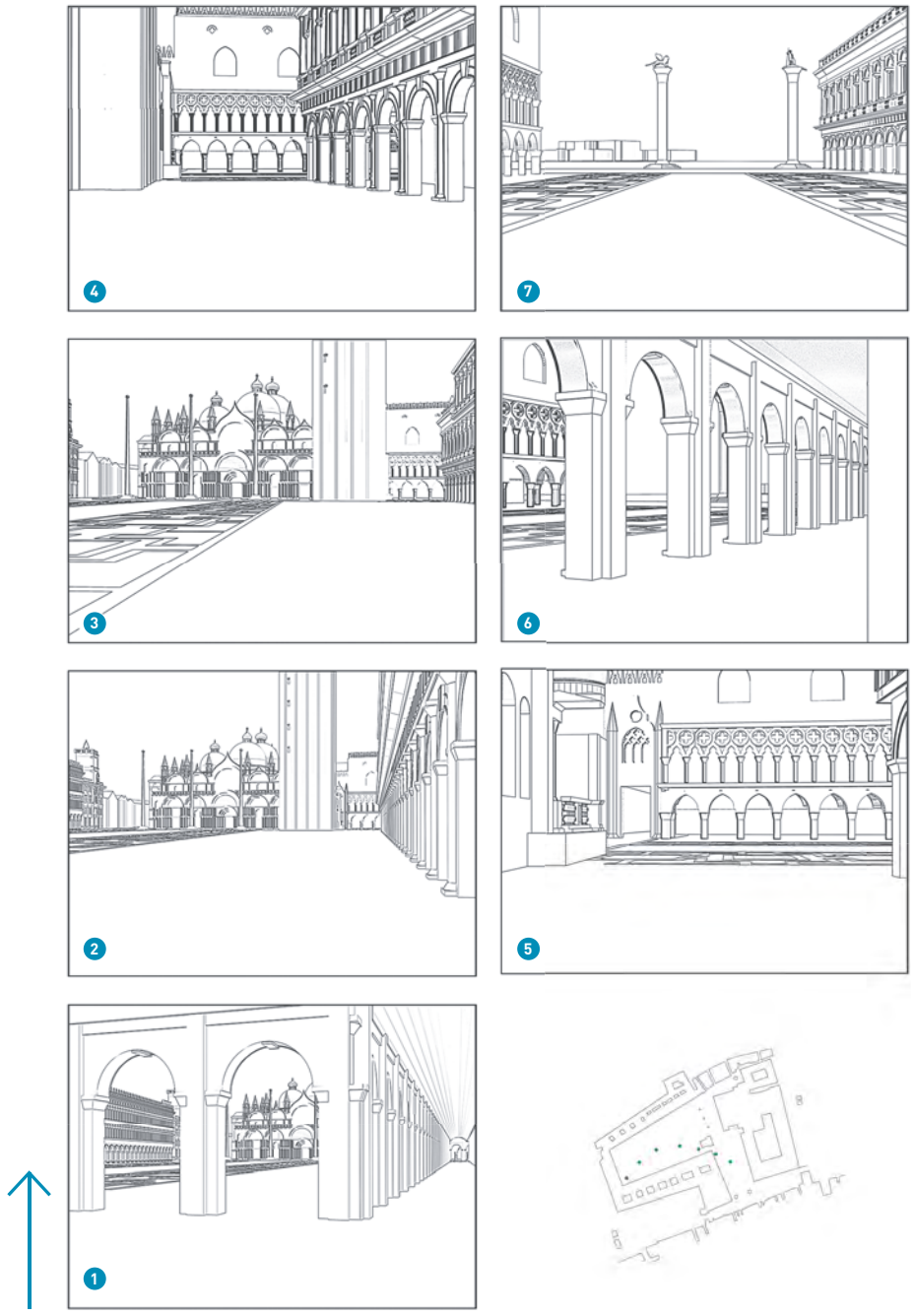


Figure 10

Serial vision from the west-end of the piazza to the south-end of the piazzetta showing the crucial role of the campanile in the changing visibility (degree of shifting scenery) of the spatial transition from the piazza to the piazzetta

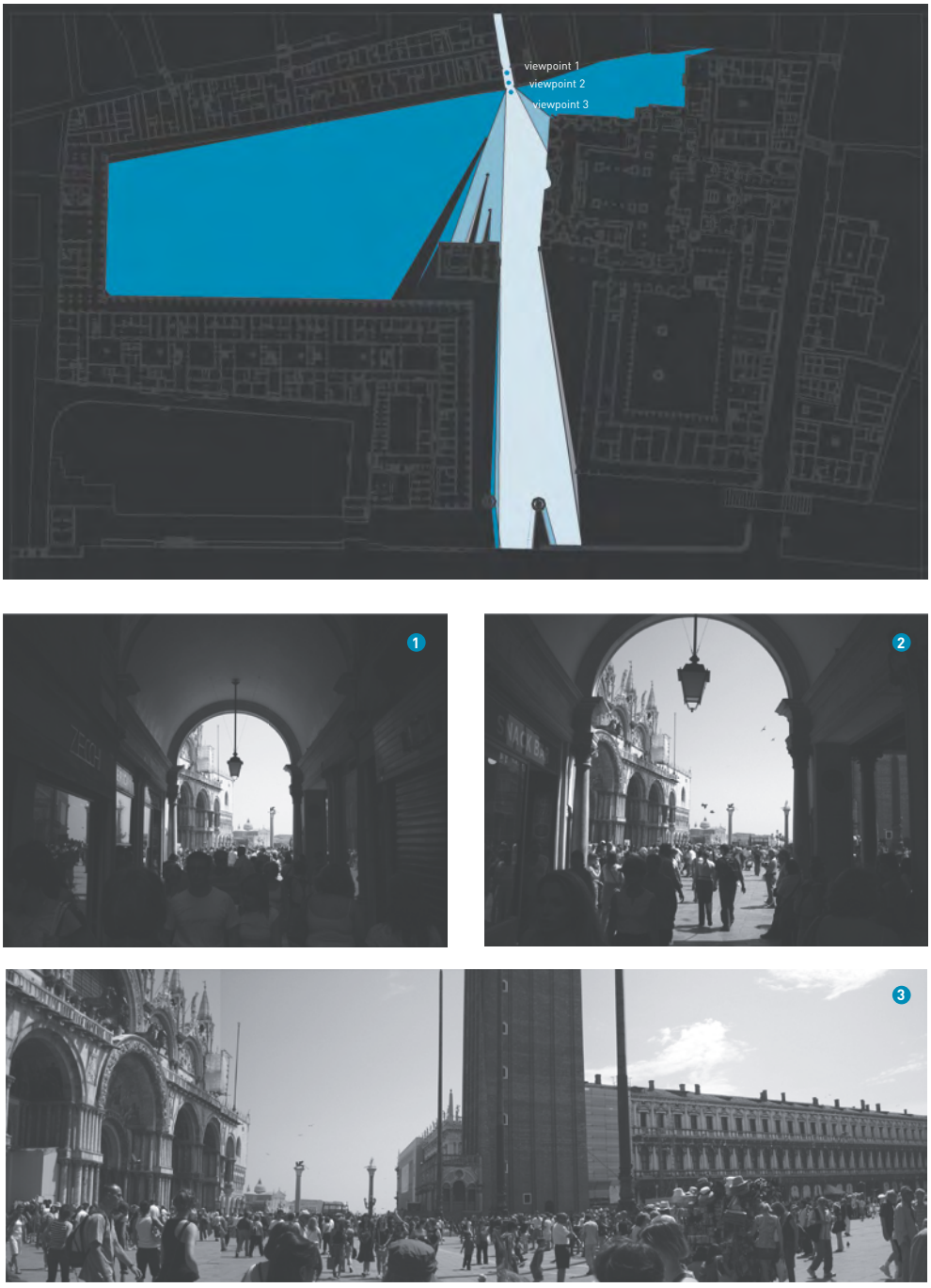
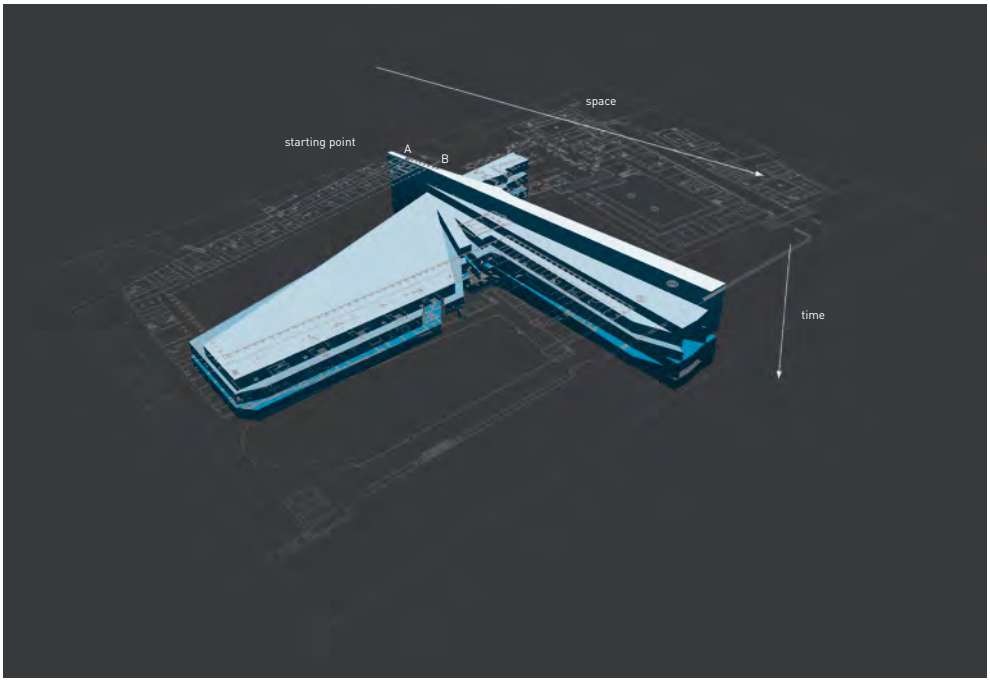


Figure 11
Sequence of views entering the square at the Torre dell'orologio

means of GIS-based isovists we have built an accurate vector based GIS-model, based on field surveys by the University of Venice (1:100; 1:500) and research by Samonà et al. (1970) and Morresi (1999).

In order to represent and apprehend the visible form of an entrance we analysed the approach to the square from the *Torre dell'orologio* (Clock Tower). This clock tower is one of the most important links between the piazza and the rest of the city. We used GIS-based isovists (at eye-level) in a sequence of viewpoints to map the perceptual order of the entrance. The sequence of isovists shows the framed views into the piazza, across the façade of the Basilica, straight out through the piazzetta, until *San Giorgio Maggiore*. On the opposite side, it provides visual reference, taking the eye past the piazza and on in the direction of Rialto. However, towards the square the optical axis points towards the piazzetta, to gradually open out over the whole piazza. This slow sequence of frontal views can also be represented as a *Minkowski-model* (Benedikt, 1979) showing the relation between visible form and time (movement). The model is a sequential stacking of individual isovists and shows the gradual change of visible space by moving forward entering the square (see figures 11 and 12).

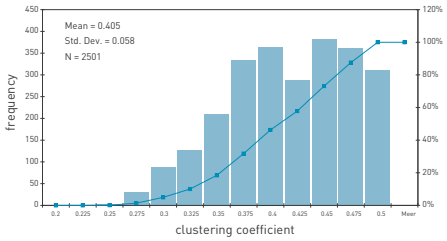
Figure 12
Minkowski-model from Piazza San Marco approached via the Torre dell'orologio. The top layer of the model represents the first isovist at point A; the bottom layer represents the isovist at point B



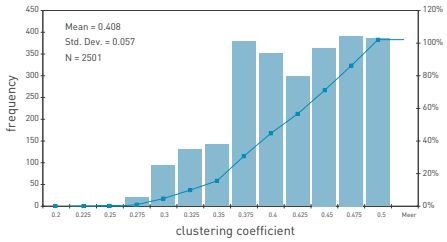
The shape and size of the isovists is liable to change with position and therefore generate specific characteristics. Because of the geometrical nature of these sight field polygons, we can compare the architectonic composition of spaces with measurements and can characterise them mathematically. Numerical measurements can quantify salient size and shape features such as perimeter, area, diameter, radius, circularity, etc. (see e.g. Batty, 2001; Rana, 2002). We can turn these measurements into a set of scalar or isovist fields. These isovist fields provide an overview of the visual properties of the architectonic space analysed. They show syntactical relations between isovists and can generate parameters such as a clustering coefficient, complexity or drift (Turner et al., 2001). But what do these parameters mean in terms of visible form? A short exploration of the clustering coefficient parameter as an example may help to illustrate this.

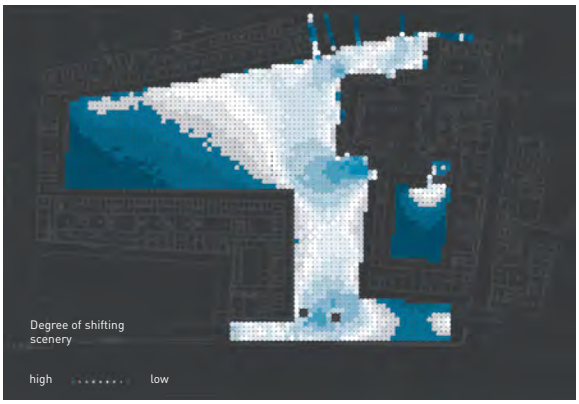
Figure 13

Degree of shifting scenery with and without the campanile. The bell-tower articulates the visual transition between the two spaces by occlusion offering a wide variation in (inter)visibility and influences both spaces (gradual transition). In the situation without the bell-tower the variation concentrates at the corner (sudden transition)



a: Degree of shifting scenery with campanile





b: Degree of shifting scenery without campanile

As we have seen, the campanile plays a crucial role in the composition of the *Piazza San Marco* as a hinge in the architectonic system that connects the two branches of the square. The campanile articulates the connection between piazza and piazzetta as an intermediate member, blocking a direct transition between the two areas of the piazza. As regards the movement of passers-by, this translates into a pause and a change in direction or division of space. This initiates an interesting shift of scenery (changing visibility), which offers spatio-visual attractiveness, arousal and clues for orientation. The shift of scenery can be mapped by using the clustering coefficient parameter in an isovist field at eye level. The clustering coefficient gives a measurement of the proportion of intervisible space within the visibility neighbourhood of a point. It indicates how much of an observer's visual field will be retained or lost as the individual moves away from that point (Turner et al., 2001). In order to show the impact of the campanile, a comparison of the piazza with and without the bell-tower can be seen. The results show that the campanile has a great impact on the variation in visibility, and influences large parts of both squares (see figures 13a, b).

5.4.3 Composed views and their sequence: Stourhead landscape garden, Wiltshire (UK)

Introduction

The finest example of a landscape architectonic composition that provides individuals with composed views or 'pictures' is the pictorial circuit of Stourhead landscape garden, especially the valley garden (Moore et al., 2000; Grandell, 1993; Watkin, 1982) (see figure 14 and 15). Here the circular walk is staged as a sequence of views with sightlines directed across a lake, terminating on small buildings placed in a larger valley landscape. Stourhead is thoroughly allegorical in nature: the monuments that terminate sightlines tell the story of Aeneas's founding of Rome. The landscape garden was designed and developed by the owners themselves, unassisted by landscape architects. In this example we analyse the framed views and their sequence.

Origins of the landscape garden

Stourhead landscape garden is located at the western edge of the Salisbury Plain (Wessex chalk lands). The plain is bordered by (deep) valleys or combes, where erosion has removed the weakened chalk and exposed the underlying upfolding older rocks as greensands (silty sand and sandstone) and gault clay (heavy non-calcareous clay) (Geddes, 2000). The Stourhead landscape is situated on a greensand ledge below the chalk downs. There are several prominent hills and ridges such as the afforested Greensand Hills of Stourhead and outliers of the chalk downs, sitting atop these greensands (e.g. Beech Knoll). In the lower parts of the ledge, in Six Wells Bottom near the junction with the underlying gault clay, the water table hits the ground surface and several springs emerge that feed the Dorset Stour (Geddes, 2000).

Figure 14
Stourhead landscape garden

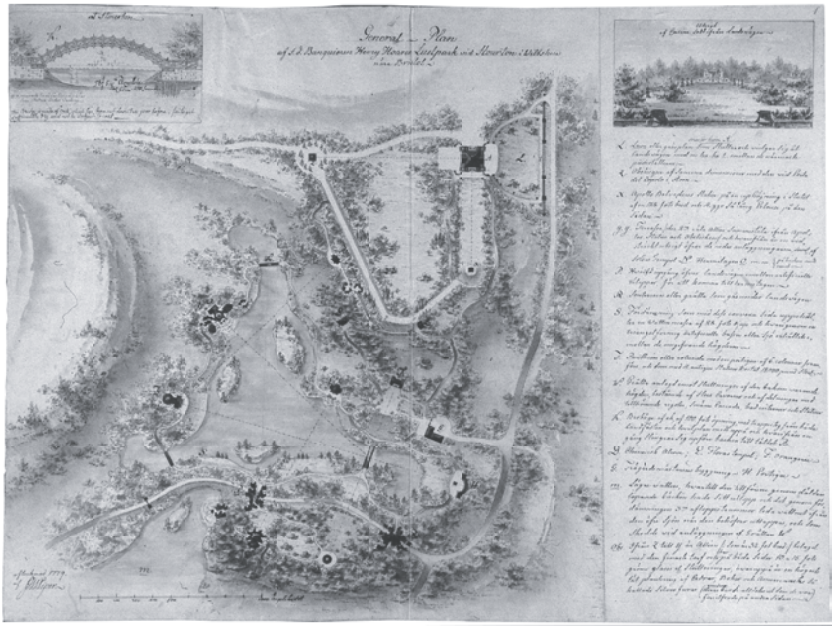


Figure 15
Plan of the valley garden at Stourhead. F.M. Piper, 1779 (Source: Royal Academy of Fine Arts, Stockholm)

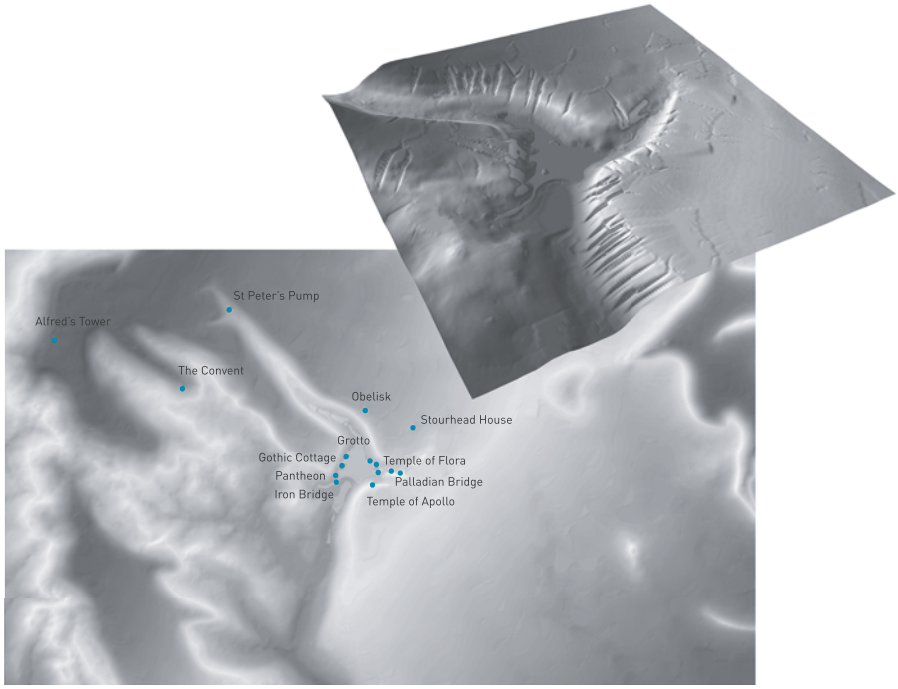


Figure 16
Stourhead in its geological context

After a long history starting around 1350 the grounds came into the possession of the banker Henry Hoare (1677-1724), member of a burgeoning financial elite. In 1718 he built a house in Palladian style named Stourhead (Woodbridge, 1970, 1996). After his death, Henry Hoare II (1705-85) set about designing the Stourhead landscape garden, assisted by Henry Flitcroft (1697-1769). About three hundred metres west from the house, at a place called *Paradise*, the grounds fall steeply to where two valleys converge they created a 'valley garden' around a lake in the period from 1743-1770. This lake was made by building a dam across the southwest corner of the valley to contain the headwaters of the Stour, and is held in by the gault clay (Woodbridge, 1970, 1996; Geddes, 2000). Around the lake he built an Arcadian landscape with framed views containing temples and other features in the manner of paintings by Claude Lorrain and Salvator Rosa. As each building or feature was made, it became a goal; a stage in a circuit walk, beginning at the house and ending at the village inn (Woodbridge, 1976). In 1785 Richard Colt Hoare (1758-1838) inherited the estate. He broadened the palette of plant material as an increasing number of exotic species became naturalised in England. He removed some features and changed the path structure considerably (Woodbridge, 1970, 1976, 1996). Stourhead has changed very little since then and in 1946 all but 890 hectares of the estate were bequeathed to the National Trust.

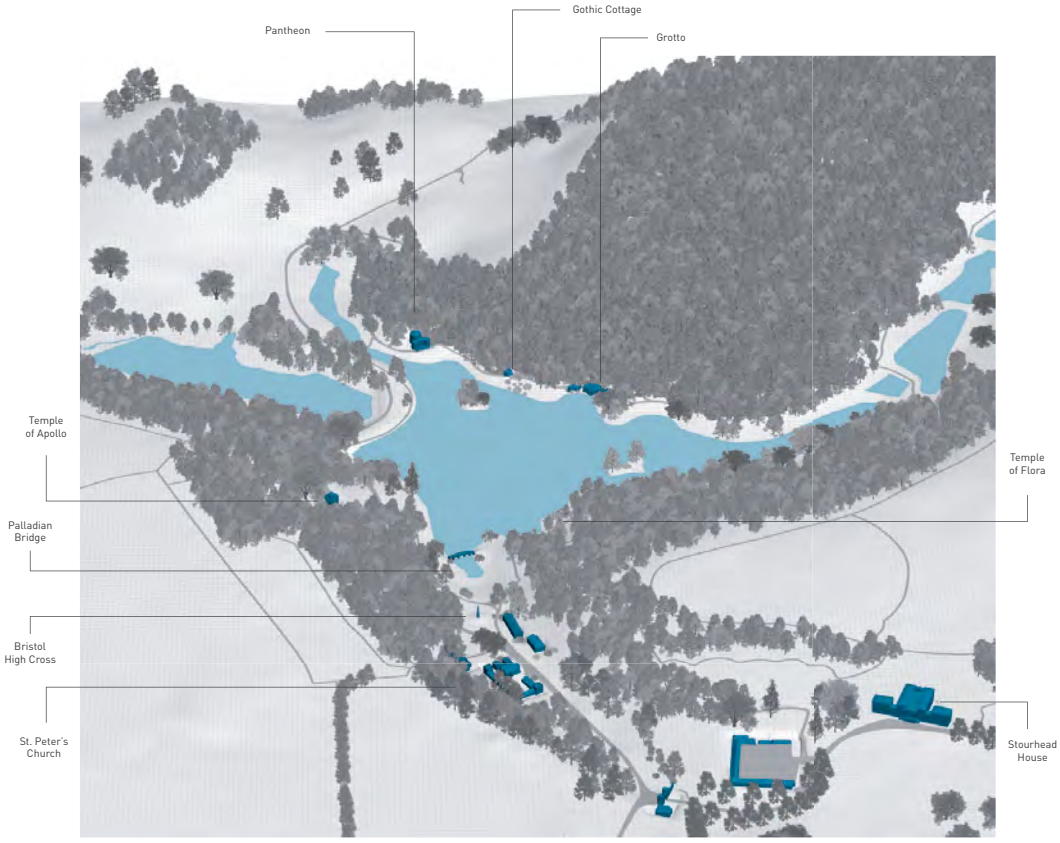


Figure 17
Three-dimensional model of the valley garden (by S. Nijhuis and J. Wiers)

Architectonic system of the landscape garden

The valley garden has a double visual structure, with axial views and circuitous, serial views with a lake as the reflecting pool mirroring the scenes. The first is about stationary vision and framed views across the lake, providing scenes with Classical and Gothic emblems dramatically juxtaposed. In fact, these strategic foci are goals, as a stage in a circuit walk and thus initiate movement. The counter-clockwise defined route directs the observer through slow-motion vision and tactile experience (going up and down) through a series of shifting views, offering sequential and gradual discovery of the various features involved. This stroll was allegorical in nature and designed as a series of compositions dissolving into each other, and is called a *pictorial circuit* (Paulson, 1975). The cinematic experience is a reflection of the visual story being told; and the storyline becomes a physical construction, starting originally at Stourhead house and ending in Stourhead's Inn (Woodbridge, 1976).

Henry Hoare probably used the text of Virgil's *Aeneid* as an important iconographic theme of Stourhead (Woodbridge, 1970, 1996). The pictorial circuit can be interpreted as a series of stations evoking Aenneas's journey from Troy to his founding of Rome, an odyssey that for Henry Hoare II might have symbolised his establishment of a family seat at Stourhead (Woodbridge, 1970, 1996). Juxtaposed on these Virgilean scenes, we find medieval, Gothic buildings and monuments, referring to England's past, like Alfred's Tower (Turner, 1979; Kelsall, 1983). This tower marks the site were the legendary king Alfred battled the Danes in 878. He is considered to be a founding father of the British Empire. In this respect the iconographic program evokes the dialogue between Aeneas, representing the founding of the Roman Empire (culminating in the Pantheon), and king Alfred, representing the founding of the British Empire (culminating in King Alfred's Tower). However, there is a lively discussion on the allegorical meaning of iconographic program among historians (see e.g. Paulson, 1975; Turner, 1979; Schulz, 1981; Kelsall, 1983). Whether or not a specific iconographic program was in his mind Hoare surely created a dream world inhabited by the gods, goddesses, and heroes of classical antiquity and England's history. As MacDougall suggested "it is likely that is was a device for creating a memory system [9] rather then a story with a deeper meaning, it was not the place to contemplate the deep philosophical or religious questions" (MacDougall, 1985). However, the attitude is clear: the landscape garden was a place for relaxation and pleasure and asked "to be explored, its surprises and unsuspected corners to be discovered on foot" (Hunt, 1989).

Hunt (2004) elaborates: "Stourhead comes to exist, it seems, in contested claims for meanings that can be shown to have been embedded in the original design by Henry Hoare on the basis of some tendentious reading of the cultural context… [However,] the richness of [the site] lies in [its] ability to provoke and promote a wider sea of emotions, ideas, stories than was ever anticipated by Henry Hoare [and its successors]". Yet, hardly any analysis offers an actual (non- or a-historical) and formal reading of the site. The following analysis of visual form reveals aspects of the tactile and sensorial potential as a basis for the performance and perception of the garden.

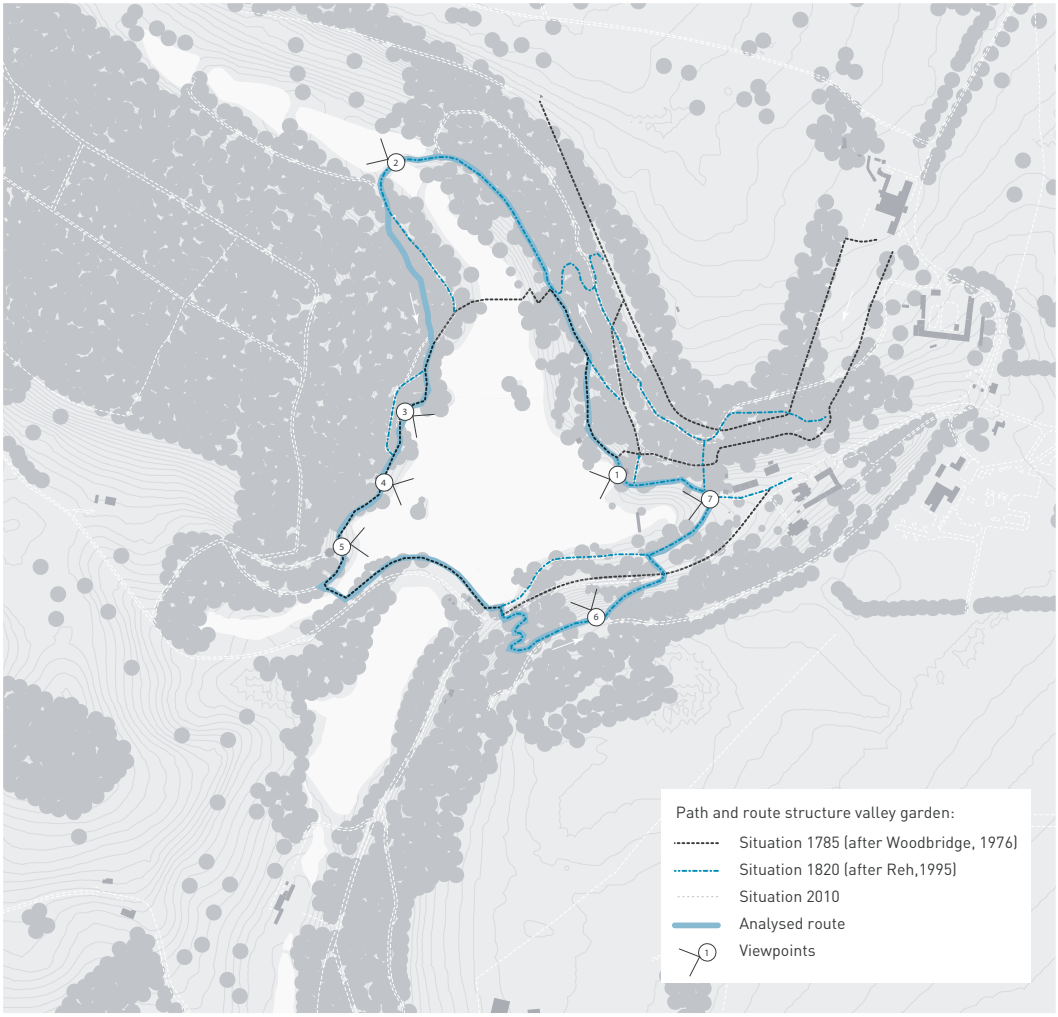
Mapping the perceptual order: framing the view and cinematic route

As previously discussed, framed views and their sequence (related to a particular route) are decisive in the architectonic system of the valley garden. The focus is on the analysis of the axial views and its formal content from designated viewpoints by means of GIS-based viewsheds. Viewsheds are very suitable because it is a topographic/vegetation space and includes differences in terrain heights with wide implications for visibility. In order to map the actual visible form of the valley garden by means of viewsheds we build an accurate raster based GIS-model, based on recent digital maps (1:2,000; 1:10,00; 1:25,000) provided by The National Trust and the British Ordnance Survey (2010). For the location and nature of the planting we used recent aerial photographs (orthographic), inventories of Woodbridge (1976, 1970, 1996) and a field

visit (2009). Finally, the reconstruction of the route and path-structure is based on research by Woodbridge (1976) and Reh (1995).

To determine the visual logic it is important to consider the original path structure, its changes and the related route, in order to determine the major viewpoints. At Stourhead there are actually three circular walks: the walk around Great Oar Pasture, the walk around the lake (valley garden) and the outer circuit to Alfred's Tower (Reh, 1995). The pictorial circuit around the lake in the valley garden and its related viewpoints is the object of study. In particular we focus

Figure 18
Path structure and related viewpoints in the valley-garden



on the major views related to the 'unchanged' path structure that facilitate the counter-clockwise stroll starting at the Temple of Flora and ending at Bristol High Cross (see figure 18).

The path structure directs the movement through the three-dimensional composition. By following the counter-clockwise circuitous route the visual form becomes cinematic, because of the sequence of staged views. The axial views are framed by extensive use of trees and laurel for under-planting. Henry Hoare II also added planting contrasting masses of light- and dark-toned trees as inspired by Pope and Kent. This palette is later extended by Richard Colt Hoare, with more exotic species (i.e. Rhododendrons), which now dominate the views (Woodbridge, 1976). As a result several composed picture-like views with a foreground, middle ground and background can be seen, reflected by the lake. Occlusion is the most powerful depth-cue involved, exaggerating the perceived distance. But also depth cues like size relative to known objects and height on the picture plane are design principles that play an important role. For example, the Pantheon is a miniaturised version of the Roman original and is located on a terrain elevation, taking the eye for a run.

Focal points within the scene are juxtaposed Classic and Gothic emblems, which function as destinations and thus initiate movement. The slow-motion vision through following the path, offers sequential frontal and/or lateral perception of scenes and gradual discovery of the various features involved. This gradual change offers a sense of scenic intricacy that arouses and sustains curiosity. Upon arrival, the focal points (i.e. the temple) are used for enjoyment and repose for those walking through the valley garden and become viewpoints for other scenes as stages in the circuit walk. By using viewsheds we can analyse the visible area from the viewpoints, measure the (angular) extent of the view and see which objects can be seen within the view (see figures 19, 20 and 21).

The viewshed-analysis points out that the optimum angular extend of the composed views corresponds with the centre of the field of vision in the range of 20-30 degrees binocular view (see table 2). As we have seen within this zone the highest degree of optical acuity is achieved. The analysis suggests that this is the decisive factor for framing the view and (visual) grouping of the focal points in the scene. It is designed 'by eye' as a three-dimensional painting or theatre, rather than using rulers and a compass. This perceptual order is also expressed in the metric length of the lines of sight between the focal points across the lake establishing the axial relationships. The average distance is about 431 metres making sure that that the artefacts and their characteristics can be recognised (see table 2). The maximum distance for recognition of characteristic elements in a landscape is about 500 metres (Van der Ham and Iding, 1971).

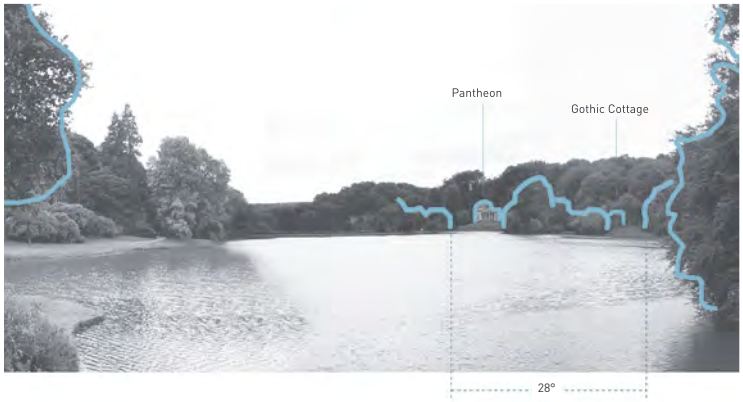
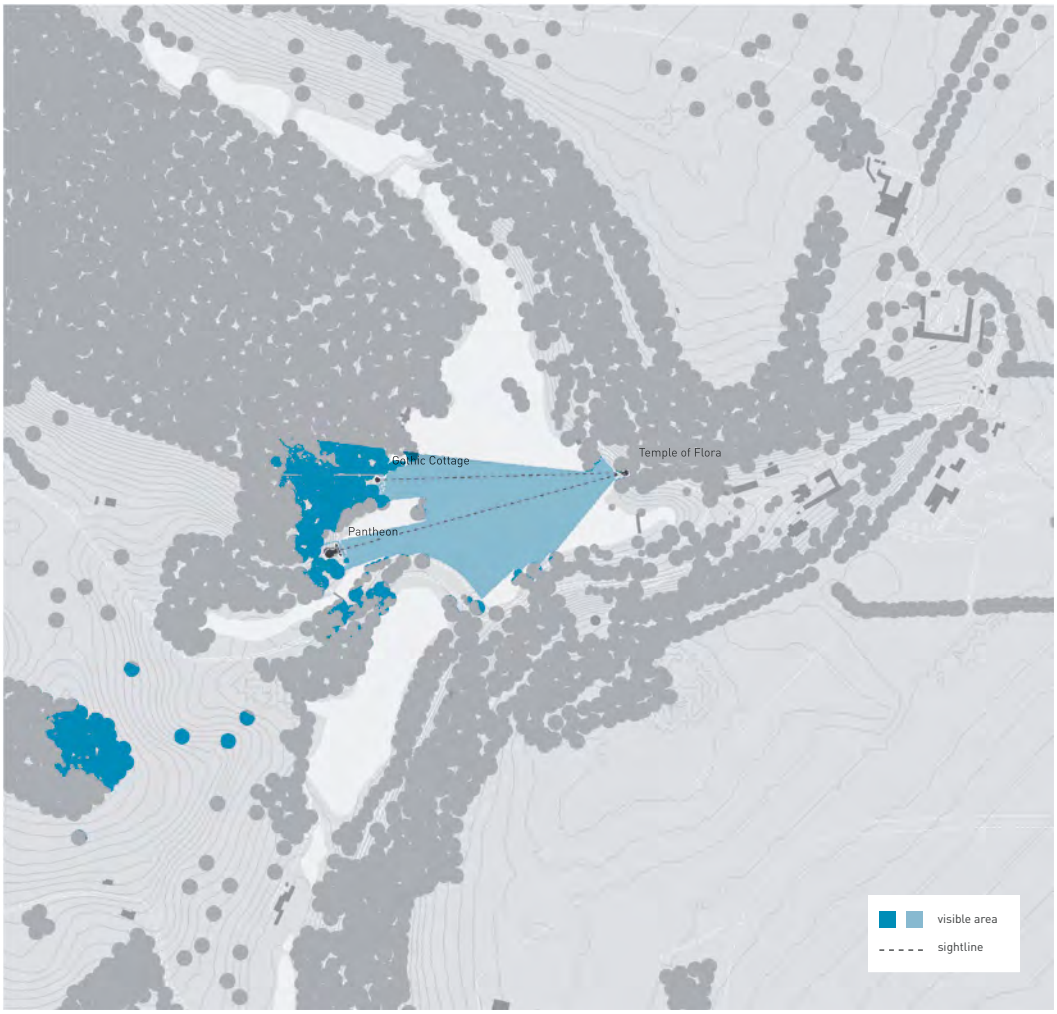


Figure 19
Viewshed analysis from viewpoint 1 (Temple of Flora) and corresponding view



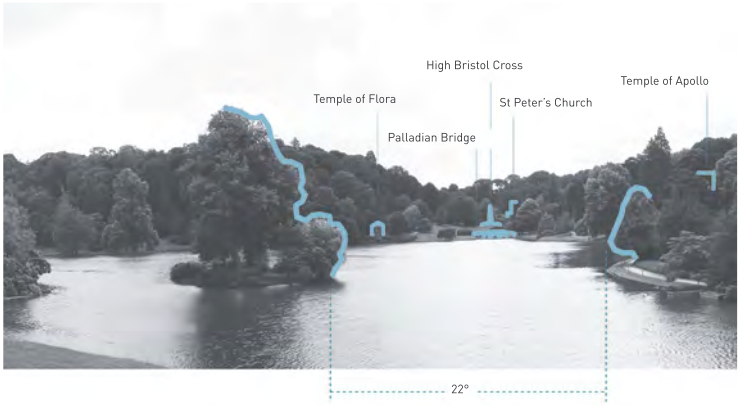


Figure 20
Viewshed analysis from viewpoint 5 (Pantheon) and corresponding view

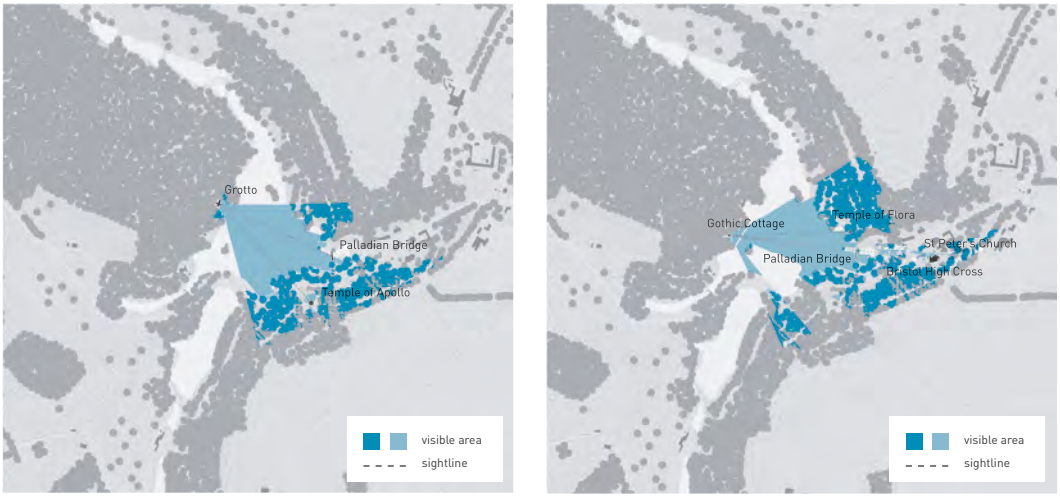


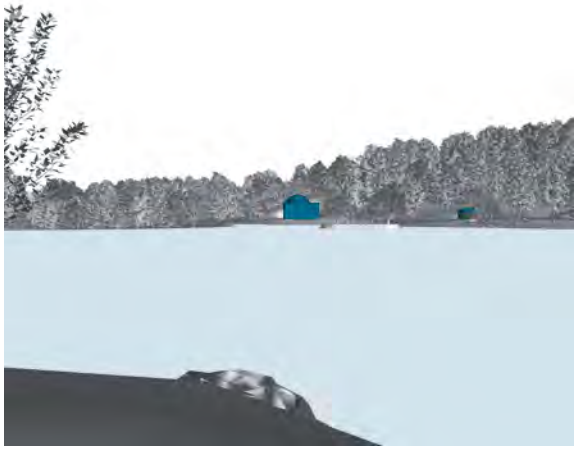
Figure 21
Viewshed analysis from viewpoint 3; Grotto (l), and viewpoint 4; Cottage (r)

Table 2
Comparison of the views; extent of the view in angular degrees and metric length of lines of sight. The optimum angular extent is determined by the occluding objects in the middle ground, framing the view that contains the focal points

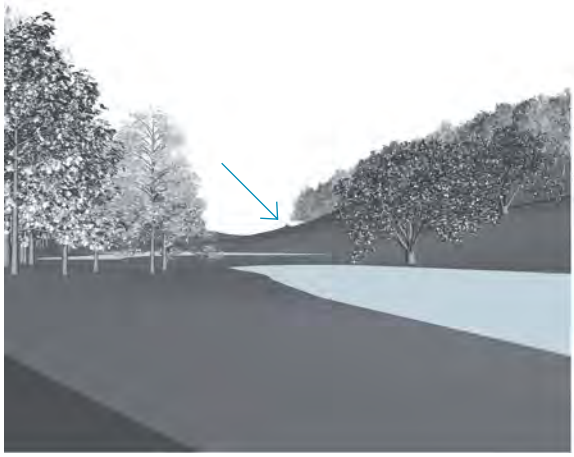
	Viewpoint 1	Viewpoint 2	Viewpoint 3	Viewpoint 4	Viewpoint 5	Viewpoint 6	Viewpoint 7	Mean	Std.dev.
	Temple of Flora	St. Peters Pump	Grotto	Cottage	Pantheon	Temple of Apollo	Bristol High Cross		
maximum angular extend of the view (degrees)	53	-	67	43	62	86	36	57,83	17,97
optimum angular extend of the view (degrees)	28	-	31	28	22	32	24	27,50	3,89
angular extend between foci	14	-	23	12	13 (30*)	60	12	22,33	18,92
maximum distance view-point - focal point (metres)	368	1440**	318	497	494	3120**	478	431,00	82,57
minimum distance viewpoint - focal point (metres)	306	-	343	305	324	320	90	281,33	94,76

measurements based on calculated viewsheds, decimal figures converted to an integer
* incl. Temple of Apollo
** outside the valley garden

With regard to the allegorical nature of the pictorial sequence organised by the circuitous route we can simply start by counting and characterising the elements within the views. Below is an overview of the findings:

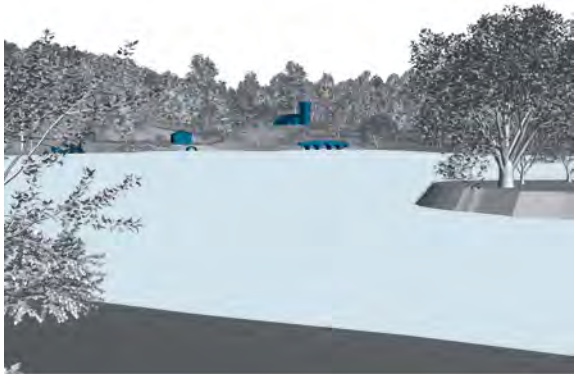


Viewpoint 1 (Temple of Flora)
Focal points within the view: The Gothic Cottage and The Pantheon (1753-54 by Henry Flitcroft: originally called the Temple of Hercules), a miniaturised version of the Roman temple

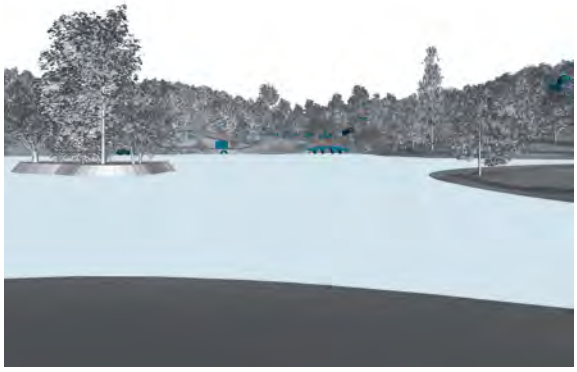


Viewpoint 2 (Saint Peter's Pump)
Focal points within the view: Saint Peter's Pump (erected 1768) in Six Wells Bottom, marking the origin of the Stour

Viewpoint 3 (Grotto)
Focal points within the view: The Palladian Bridge and The Temple of Apollo (1765 by Henry Flitcroft)

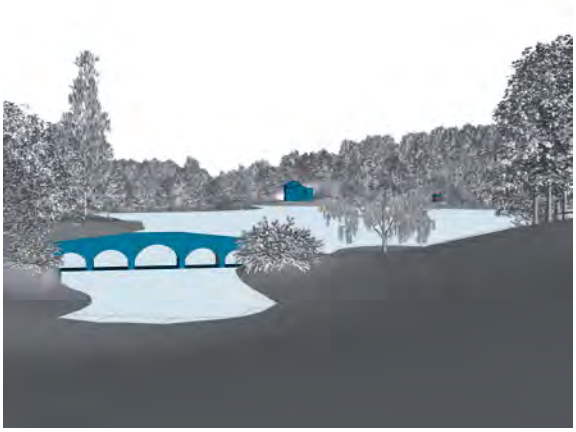


Viewpoint 4 (Gothic Cottage)
Focal points within the view: The Temple of Flora (1744-46 by Henry Flitcroft; originally called Temple of Ceres), The Palladian Bridge, The Bristol High Cross (derived from High Street of Bristol and erected near the entrance in 1765) and Saint Peter's Church



Viewpoint 5 (Pantheon)
Focal points within the view: The Temple of Flora, The Palladian Bridge, The Bristol High Cross, Saint Peter's Church and The Temple of Apollo

Viewpoint 6 (Temple of Apollo)
Focal points within the view: The Obelisk (1839-40), Alfred's Tower (1762 by Henry Flitcroft), The Rockwood Boathouse (near Temple of Apollo), The Grotto and The Pantheon. Measurements point out that Alfred's tower was visible only with young, low trees on the Greensand Hills. As the trees matured and grew taller the tower became hidden from view.



Viewpoint 7 (Bristol High Cross)
Focal points within the view: The Palladian Bridge, The Cottage and The Pantheon

The analysis show that almost every view contains juxtaposed Classical and Gothic architecture suggesting an allegorical dialogue between historical events, especially due to the fact that there is a balanced amount of artefacts within the view counting an even number of emblems. In other words, every Classical element is counterbalanced by a Gothic iconographic object. It also interesting to consider the relation of the viewpoints and the course of the path. In a horizontal direction there is a certain timing, with varying intervals, between the major views. In vertical direction the relation is in going upward and downward e.g. descending to the Grotto, ascending to the Pantheon and the steep climb to the Temple of Apollo (see figure 22). Whether this tactile experience and the related staging of views reflects a story with a deeper meaning, or is a kind of memory system facilitating pleasure and relaxation, it is a rich site which promotes and provokes a wide range of emotions, ideas and stories.

5.4.4 Conclusions

Mapping the visible form by means of GIS revealed particularities of the perceived architectonic space and included visual concepts as described in section 5.3. The example of *Piazza San Marco* showcases that it enables measurement of space relationships with isovists and isovist fields, such as the sequential unfolding of visual space at the entrance of the square and the hinge-effect of the bell-tower introducing a high degree of shifting scenery. At Stourhead landscape garden the analysis of the angular extent, the visual coverage of (composed) framed views and counting focal points by means of viewshed analysis, especially their angular extent in relation to the physiology of vision and the balanced amount of emblematic focal points within these views, gives an interesting result. It enabled the measurement of their sequential

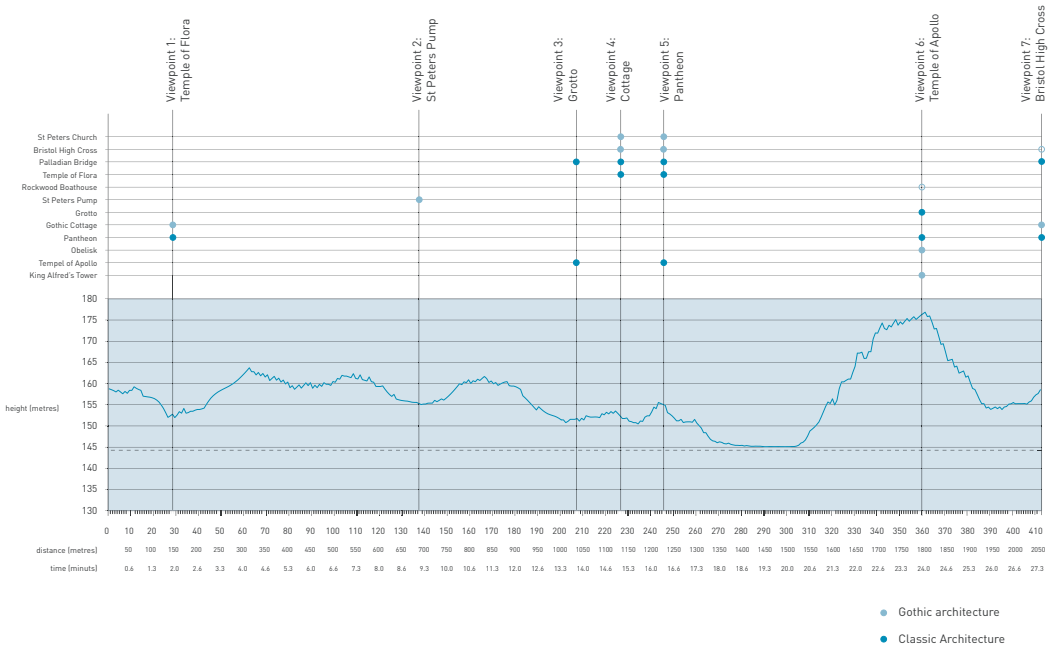


Figure 22

The stroll at Stourhead explored. The sequence of the views in relation to distance, time and height of the path

relationship in time based on slow-motion vision by walking, taking into account tactile properties such as differences in heights along the course of the path.

5.5 DISCUSSION

By the conversation with actual (and conceived) sites and the representations of their visible form researchers in landscape architecture acquire deeper understanding as a basis for knowledge-based design. By mapping the physiognomy of the composition, as it is encountered by an individual within it, moving through it, it is possible to acquire object related and typological design knowledge on visual aspects. GIS turned out to be a useful vehicle for systematic and transparent mapping of the visible form. The examples showcase that GIS-based isovists and viewsheds have the potential of measuring visual phenomena which are often subject of intuitive and experimental design, taking into account physiological, psychological, and anthropometric aspects of space. It offers the possibility to combine general scientific knowledge of visual perception and wayfinding with the examination of site-specific design applications.

In comparison to important landscape design research studies on visible form in the Dutch academic context, such as the seminal works of Steenbergen and Reh (2003), Baljon (1992), Warnau (1979) and Bijhouwer (1954), it seems that GIS deepens and broadens the body of knowledge in landscape architecture in two ways by:

(1) *Following the discipline and developing specific aspects of it:* by using GIS we can map the 'same types of design-knowledge' but in a more precise, systematic/transparent, and quantified manner. It makes for precise delineation and alternative ways of representation of the visible landscape. By using GIS it is possible to reproduce and transfer methodology; it is a transparent and systematic approach for advanced spatial analysis. It also comprises of measurement (quantities), testing and verification of expert knowledge, or known visual phenomena in landscape architecture.

(2) *Expanding the field by setting in motion fundamental new developments*: by using GIS we can map 'new types of design-knowledge' by advanced spatial analysis and the possibility of linking up/integrating other information layers, fields of science and data sources. GIS offers the possibility of integrating and exploring other fields of science (e.g. visual perception, wayfinding studies) and dealing with complexity (more variables). Also the availability of other types of data such as Web 2.0, terrestrial LiDAR, LBS, and Crowd Sourcing is important in this respect. This offers the possibility to enrich formal reading by revealing tactile and sensorial potentialities of a design, which was hardly possible before, and also expands the analysis with data derived from psychological and phenomenological approaches addressing matters of reception of a design.

Although there is lot left to be explored in examples, this research exemplified that it can offer clues for deeper understanding of particular spatial phenomena that constitute visible form. This is important for acquisition of design knowledge, but is also crucial in management and restoration of sites like Stourhead [10].

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NOTES

[1] For an elaboration on scientific perspective and the influence it exerted on architecture see Pérez-Gómez and Pelletier (1997).

[2] The term landscape architecture (*architecte-paysagiste*) was coined by Jean-Marie Morel in 1803 and marked the eclipse of the 'new' discipline (Disponzio, 2002). Landscape architecture as an English term appeared for the first time in a book title: On the Landscape Architecture of the Great Painters of Italy (Scott, 1828), and was subsequently used by Frederic Law Olmstead and Calvert Vaux at the design competition for the Central Park in New York in 1858. The profession became official, when in 1863 the title Landscape Architect was first used by the state-appointed Board of Central Park Commissioners in New York City (Steiner, 2001; Evert, 2010; Turner, 1990).

[3] This corresponds with space-conceptions as described by Montello (1993), Mark (1993) and Tversky et al. (1999).

[4] You can even consider it a science: *strollology* or *promenadology* as proposed by Burckhardt (2008). It engages in the study of sequences with which the observer is confronted by within the spatial environment.

[5] Wayfinding refers to the cognitive and behavioural abilities of humans to find a way from an origin to a destination, see Golledge (1999).

[6] This is not exclusively restricted to The Picturesque as a movement. In this tradition Picturesque is an aesthetic category derived from the idea of designing (urban) landscapes to look like pictures and was advocated by landscape architects like William Kent and urban designers like Camillo Sitte and Gordon Cullen.

[7] The invention/description of the linear perspective by Filippo Brunelleschi as written down by Leon Battista Alberti played a crucial role in the architectonic compositions such as Pienza (see e.g. Pieper, 2000, 2009). The notion of pictorial staging or scenography was introduced by Hans Vredeman de Vries in his book *Sevenographia, sive perspectiveae* (1560), showing décor-like architectonic settings, using the rules of linear perspective to fit objects logically into surrounding space (Vroom, 2006; Mehrtens, 1990).

[8] See also Van der Ven (1980) and Doxiades (1972).

[9] Memory could be developed by establishing a mental image of a place inhabited by or 'decorated' with views. See MacDougall (1985) on this matter.

[10] The author intends to elaborate the research on Stourhead and show applications for management and conservation.

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