Make Way for *WayMaker*

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Abstract

We describe a tool enabling non-professionals to create digital layouts for large-scale graphical virtual environments. The design tool is based on "elements of the city image" as described by the urban planner, Kevin Lynch (1960). These elements serve as both organizational principle and navigational aid. Further work is needed to situate the tool within a virtual environment so that output from the tool is transformed as extensions to the virtual world. Here we describe the theoretical basis for the tool, implementation of an initial prototype that simulates a virtual world through a series of composited frames, and next-step revisions stemming from users' experiences with the prototype.

> *Long ago the urban theorist Kevin Lynch pointed out the fundamental relationship between human cognition and urban form – the importance of the learned mental maps that knowledgeable locals carry about inside their skulls. These mental maps, together with the landmarks and edges that provide orientation within the urban fabric, are what make a city seem familiar and comprehensible.* – (Mitchell, 1995, p.43)

Rationale

People sometimes speak of "making a way" through an environment or problem space. This turn of phrase captures an important aspect of navigation: the process of finding one's way involves a parallel process of constructing, of developing a conceptual representation of the space and its features. Wayfarers are as active conceptually as they are physically. Their efforts pertain to internal as well as external actions. In our work, wayfarers' conceptions become the basis of a design tool for creating or extending virtual environments. We base the tool on Kevin Lynch's observations of how people "image" the city – that is, how they create and remember mental images of the large-scale environments in which they live.

In particular, Lynch studied how people think about the structure of their cities. From verbal and pictorial accounts, he derived five basic elements of the city image: districts, paths, edges, nodes, and landmarks. In *The Image of the City*, Lynch describes how people use these elements to organize a mental image of the places they inhabit:

> In the process of way-finding, the strategic link is the environmental image, the generalized mental picture of the exterior physical world that is held by an individual. This image is the product both of immediate sensation and of the memory of past experience, and it is used to interpret information and to guide action. The need to recognize and pattern surroundings is so crucial, and has such long roots in the past, that this image has wide practical and emotional importance to the individual. (Lynch, 1960, p. 4)

Although mental images are individualistic, Lynch found that people represent certain city elements consistently. *Districts* are broad regions, such as neighborhoods, that have some common, identifying character such as brick sidewalks or rows of brown-stone buildings. *Paths* are the channels along which people move; they may be narrow like sidewalks or wide like roads. *Edges* are distinct boundaries between one region and the next; they may function as barriers or seams. *Nodes* are strategic points, foci to and from which people travel. *Landmarks* are punctuation points used for general orientation; they may be distant or local.

Urban planners and designers recognize the usefulness of these elements not just in reflecting on the structure of the city, but also in creating it. Lynch's elements are insufficient to characterize the experience of an urban environment. However,

professionals assume that a well-designed, "imageable" city incorporates the elements that Lynch articulated (Banerjee & Southworth, 1990). In fact, these elements are embedded in the culture of urban planners and designers, having become the basis of a pictorial vocabulary that many professionals use to develop and communicate their concepts and plans (e.g., Ibid.; Lynch, 1981). Thus, by basing *WayMaker* on Lynch's elements, we are drawing from well-honed practice as well as addressing a current problem in virtual environment design: as virtual environments become more commonplace, a greater variety of people will be involved in developing them.

Participants in text-based multiuser environments like "MUDs" and "MOOs"[1] typically interact with each other, but also with the environment. They use an associated programming language to construct characters, objects, and spaces within the virtual domain (Curtis, 1992; Rheingold, 1993; Bruckman & Resnick, 1995; Mitchell, 1995; Bruckman, 1997). However, this constructive component is not easily transferred to graphical environments. The tools for developing images and structures tend to be complex and sophisticated, often requiring professional expertise in order to produce a satisfying result. Yet, graphical virtual environments are emerging as milieus with potential for broad use in learning, entertainment, and socializing (Benedikt, 1991; Anderson et al., 1995; Shaw, 1995; Darken, 1996; Darken, & Sibert, 1996; Moshell & Hughes, 1996; Strohecker, 1997; Strohecker & Barros, 1997; Turkle, 1995). Clearly we need to develop easily usable tools to support participants' interactions, including world construction, navigating, and wayfinding.

In a premonitory observation, Lynch corroborates the need for user-extensible media in addressing this problem:

> If an image is to have value for orientation in the living space, it must have several qualities. It must be sufficient, true in a pragmatic sense, allowing the individual to operate within his environment to the extent desired. The map, whether exact or not, must be good enough to get one home. It must be sufficiently clear and well integrated to be economical of mental effort: the map must be readable. It should be safe, with a surplus of clues so that alternative actions are possible and the risk of failure is not too high. If a blinking light is the only sign for a critical turn, a power failure may cause disaster. The image should preferably be open-ended, adaptable to change, allowing the individual to continue to investigate and organize reality: there should be blank spaces where he can extend the drawing for himself. Finally, it should in some measure be communicable to other individuals. (Lynch, 1960, p. 9)

WayMaker provides a basic set of symbols that people can use to create maps reflecting individualized conceptions of a space. The maps can be easily modified through an

[1] "MUD" means Multi-User Domain; "MOO" means "MUD Object-Oriented."

ongoing interactive process. The toolkit includes provisions for added detail and redundancy of cues. Because the number of symbols is small and their character is straightforward, individuals can interpret one anothers' designs. The mapped spaces may be imaginary or real; in either case *WayMaker* effects appropriate changes of representation, view, and scale as people diagram and explore a virtual domain.

Scope

Recently researchers have experimented with Lynch's structural elements in facilitating navigation through large-scale virtual environments (Darken and Sibert, 1996) and in visualizing large information spaces (Ingram and Benford, 1995). Our concern is with user-extensibility of graphical virtual environments.

WayMaker users work directly with representations of Lynch's elements. Each symbol corresponds to an aspect of city form. There are five basic symbols, representing districts, paths, edges, nodes, and landmarks (Figure 1). Using the symbols to develop a map-like diagram, the user assumes a bird's-eye view and imagines the virtual domain at large scale. The user can then modify the symbols to specify details such as the visual character of districts and landmarks. The software transforms the user's design into street-level scenes representing a walk through the domain (Figure 2).

For the initial prototype, we worked with reproductions of paintings by Paul Cézanne to form the street-level scenes. Cézanne's works comprise studies of the relationship of the built to the natural environment (Figure 3). The impressionistic imagery lends itself to our technique of compositing simulated views through a virtual domain.

WayMaker maps and scenes depict only large-scale, structural features of a space. Creation and depiction of other features of a virtual world, such as characters and architectural forms, would require additional tools. Furthermore, the current *WayMaker* prototype focuses on the kit for creating maps moreso than on rendering the world. Therefore the street-level, "walkthrough" scenes for our prototype need only be suggestive. Their purpose is to help users understand the connection between Lynch-style maps and the virtual spaces that they represent.

Using *WayMaker*

To begin designing an environmental image, the user simply drags symbols into the working area (Figure 4). District, edge, and path symbols can be stretched and curved to take on various shapes. Nodes and landmarks can be placed anywhere in the diagram as elements to be encountered along the walkways. Paths, landmarks, and nodes are available in two sizes: a path may function as boulevard or alley; large landmarks may appear as towers; small landmarks may become smaller structures or banners marking points of interest (Figure 5). Users can add details to indicate a sensual quality about the activity associated with nodes. Menu selections fill node symbols with imagery suggesting moods such as bustle or calm (Figure 6). The experience of such sensory

details in the walkthrough depends on the image and sound databases that the program accesses in composing scenes in a virtual world. We excerpted portions of various Cézanne paintings in order to form an image database for the initial prototype. Users can select from reproductions of the paintings in order to specify the character of a given district (Figure 7).

We interpreted these Cézanne paintings according to a classic perspectivist framework, in which side planes are defined by diagonals that converge on a vanishing point along the horizon (Janson, 1962; Oles, 1988) (Figures 8 and 9). Each scene in a walkthrough of the virtual domain is comprised of side planes, ground, back, and sky. We established ranges within which the measure, and sometimes the number, of each component can vary within a single district (Figure 10). Variation from district to district comes from the number and measure of sub-elements within side panels (bases, facades, and roofs). Such variations ensure richness in depictions of the virtual world (Figure 11).

When the user has finished specifying details of the layout, s/he can indicate a walkway route through the virtual world (Figure 12). The program then loops through a series of functions: it ascertains which district the walkway is traversing, selects the framework that corresponds to that district, draws from the associated database of images in fitting components within appropriate parts of the framework, then varies the framework for the next scene, again filling it with image components, and so on. The result is a series of scenes that vary subtly, frame by frame, and distinctly, district by district (Figure 13).

Thus the user-designed map undergoes three transformations. The representation changes from a diagram composed of abstract symbols to recognizable, though impressionistic, imagery. The view changes from bird's-eye to street-level. The scale changes from that of a city, town, or region to that of a human stroll.

Further Work

We believe that the best way to support users in appreciating these transformations is to provide simultaneous displays of the map and the walkthrough scenes (c.f. Brooks, 1986). This is the most important realization stemming from users' trials of the prototype. In the next version, the display will indicate each scene's location within the diagram, as the walkway sequence plays out. This double display will emphasize connections between user-created diagrams and the program-constructed virtual world. Users should be able to go quickly back and forth between the mapping and walkthrough modes, both to facilitate ongoing creation of the map and to promote understandings of the spatial relationships represented by the diagram and walkthrough scenes.

Placing the walkway ribbon is currently an intermediary step between diagramming and seeing the walkthrough. We are developing a new approach that will eliminate this step and enable users to follow in the walkthrough the same paths they create as part of their diagrams. This treatment will benefit from the simultaneous display of map and

walkthrough scenes, and will require occasional indications of direction as the viewer encounters intersections.

We also plan refined placement of nodes and landmarks within the views, the addition of bursts of sounds and images to suggest human activity associated with nodes, and variation of the width of side planes corresponding to curves in a walkway. Interesting questions about perception arise in determining how many views to generate for each district. Currently the software generates views along roughly equal measures of the walkway ribbon, so the number of views depends on the size of the district and the length of the route through it. However, varying this pattern could strongly influence notions of pacing or attention. One is likely to see more detail when moving slowly, even though the distance traveled may be the same as when breezing through another district.

WayMaker diagrams could be associated with any number of prepared databases, yielding any number of apparent worlds. We have implemented the prototype on a personal computer and are using two-dimensional imagery for both the construction kit and the walkthrough sequences. *WayMaker* could easily use alternate 2D databases for the walkthrough scenes. For example, we could develop image databases from Picasso paintings or sets of photographs instead of the Cézanne imagery. In fact, several users have expressed the desire to incorporate their own imagery for the walkthrough sequences. This would be possible, provided the images were segmented and named appropriately, and provided the viewer saw the perspectivist composites with whatever degree of suspended disbelief the image set warranted. We believe that impressionistic imagery would tend to work especially well with the compositing technique, but surely there is room for experimentation and individual taste. Furthermore, with appropriate development, the information in the maps could be translated as 3D arrangements of the structural elements. Again, the relative placements of the elements are key point; images representing the elements in the walkthrough are interchangeable. Thus the current depictions of scenes in a *WayMaker* virtual space are independent of the question of whether or how Lynch's formulations may be broadly useful as a basis for design and construction tools for virtual worlds.

Implications

We expect users' further experiences with *WayMaker* to inform our understanding of how people think about and organize virtual space, what kinds of virtual places they would like to "inhabit," and ways in which manifestations of Lynch's elements could become useful, feasible additions to the repertoire of tools for graphical multiuser environments. Some of the data should be interesting from a cognitive science perspective as well. The interaction technique of constructing representations of an environment is based on theories of spatial cognition focusing on knowledge creation rather than knowledge acquisition (Gruber & Vonèche, 1977; Harel & Papert, 1991; Papert, 1980; Piaget, 1951/1929, 1970/1946; Piaget & Inhelder, 1967). The "constructionist" design will support studies of individual differences from a developmental perspective.

Researchers in spatial cognition focus on two kinds of conceptual growth: "development of fundamental concepts of space, and the further differentiation and elaboration of these concepts into the development and representation of large-scale environments" (Hart & Moore, 1973, p. 248). The developmental psychologist and genetic epistemologist Jean Piaget was concerned with growth of fundamental concepts; the urban planner and designer Kevin Lynch was concerned with their application and nurturance in large spaces. Although these researchers worked at different scales and in different domains, they shared an interest in how individuals' conceptions of space grow through interactions with the physical environment (Piaget & Inhelder, 1967; Lynch, 1960). *WayMaker* can support studies of cognitive development from both perspectives. We hypothesize that this combination may yield results in an apparently different but deeply related domain: Lynch's elements are essentially topological. In using them to plan the structure of virtual places, users may deepen their understandings of this type of mathematical relationship as well as improving spatial skills such as orientation and navigation (Beth & Piaget, 1966; Papert, 1980; Strohecker, 1991).

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Acknowledgments

Painting reproductions are from (Machotka, 1996): Ferme à Montgeroult, 1898, (v. 656; r. 833), 64 x 52 cm, Lloyd H. Smith, Houston; Maisons en Provence – le vallon de Riaux près de l'Estaque, 1882-83, (v. 397; r. 438), 65 x 81 cm, National Gallery of Art,

Washington, Collection of Mr. and Mrs. Paul Mellon; Le Moulin sur la Couleuvre à Pontoise, 1881, (v. 324; r. 483), 73 x 91 cm, Nationalgalerie, Berlin; Vue sur l'Estaque, 1882-85, (v. 407; r. 514), 60 x 73 cm, Private Collection, New York; Route tournante à la Roche-Guyon, 1885, (v. 441; r. 539), 62 x 76 cm, Smith College Museum of Art, Northampton, MA; Le Château de Médan, 1879-80, (v. 325; r. 437), 59 x 72 cm, Glasgow Museums: The Burrell Collection; Haneau à Payennet près Gardanne (formerly La Sainte-Victoire, Environs de Gardanne), 1885-86, (v. 435; r. 572), 63 x 92 cm, Presented to the U. S. Government in memory of Charles A. Loeser; L'Eglise Saint-Pierre à Avon (formerly Une rue à Aix), 1891-92, (r. 327), 47 x 31 cm, Collection Phyllis Lambert on loan to the Centre Canadien d'Architecture, Montreal; La Maison de Bellevue, c1890, (v. 655; r. 691), 60 x 73 cm, Musée des Beaux-Arts, Geneva; Gardanne (l'après midi), 1885-86, (v. 431; r. 571), 80x64 cm, Brooklyn Museum, New York, Ella C. Wodward and A. T. White Memorial Funds.

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Figures and Captions

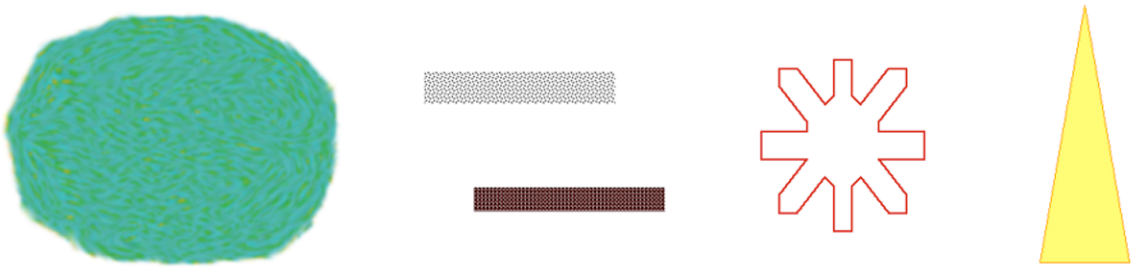
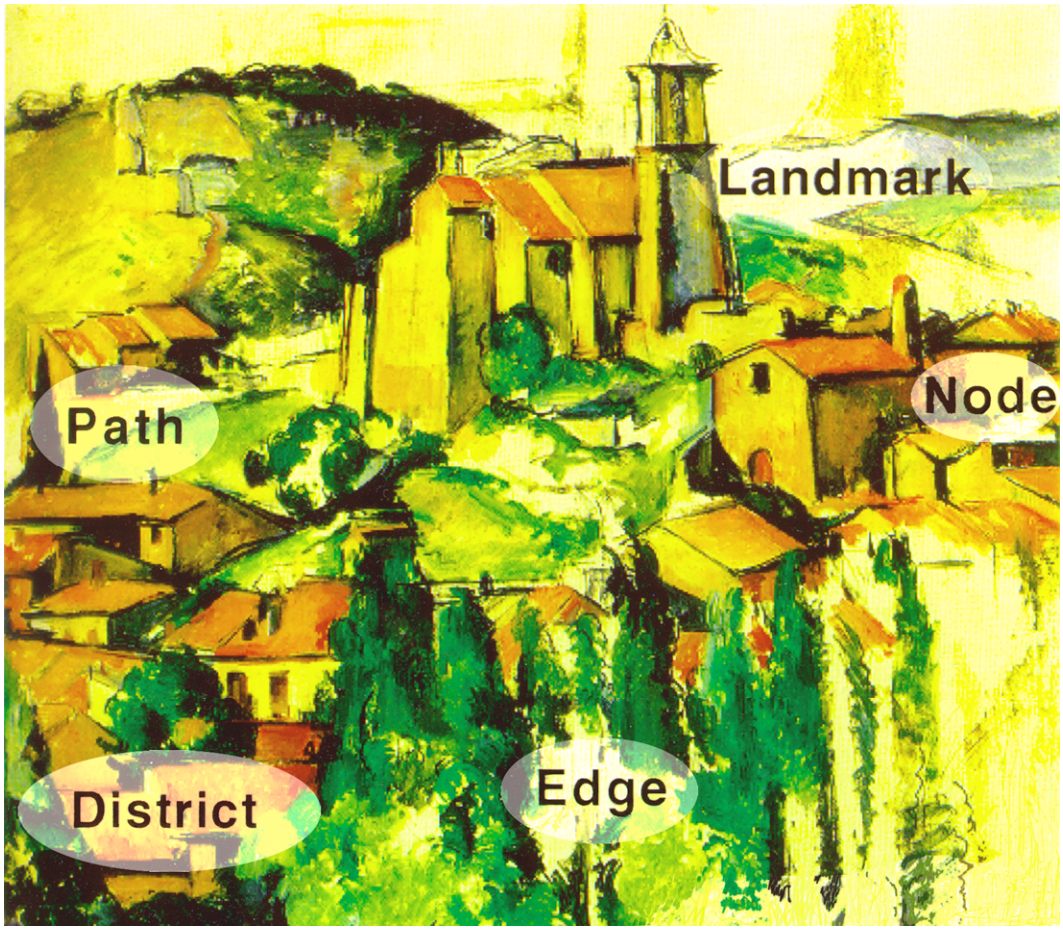


Figure 1. Symbols of Kevin Lynch's five structural elements of the city image. *WayMaker* users design virtual environment layouts through direct manipulation of these symbols.

Painting and photograph excerpts from Machotka, P. (1996). Painting: *Ferme à Montgeroult*, 1898.

Figure 2. Abstract overview to recognizable street scene. *WayMaker*'s pictorial vocabulary illustrates relative placements and sensory attributes of three elements within a district. A triangle becomes a landmark representing a memorable building; an edge demarcates the end of the observer's path.



Painting reproduction from Machotka, P. (1996): *Gardanne (l'après-midi),* 1885-86.

Figure 3. Lynch's elements can be found in the context of city renditions such as those by Paul Cézanne. These impressionistic visuals record his analyses of human-scale environments and the relationship of the built to the natural environment.

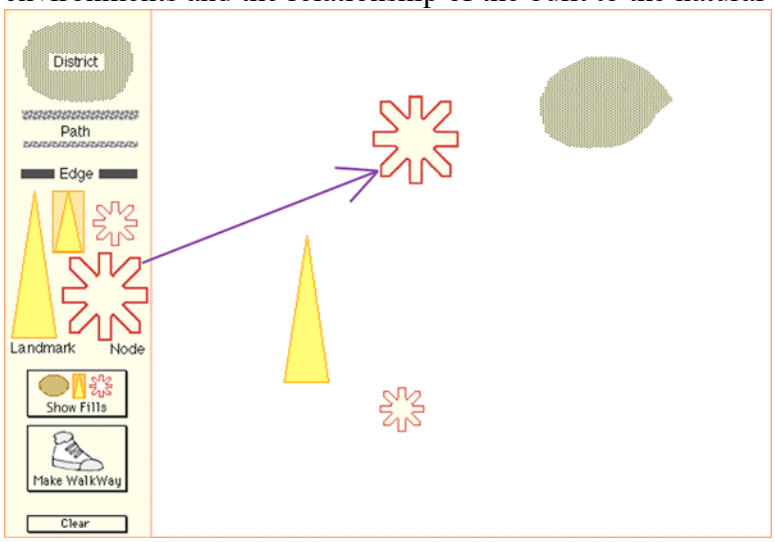


Figure 4. Representations of Lynch's elements are malleable forms with which *WayMaker* users can craft a diagrammatic image of a virtual space.

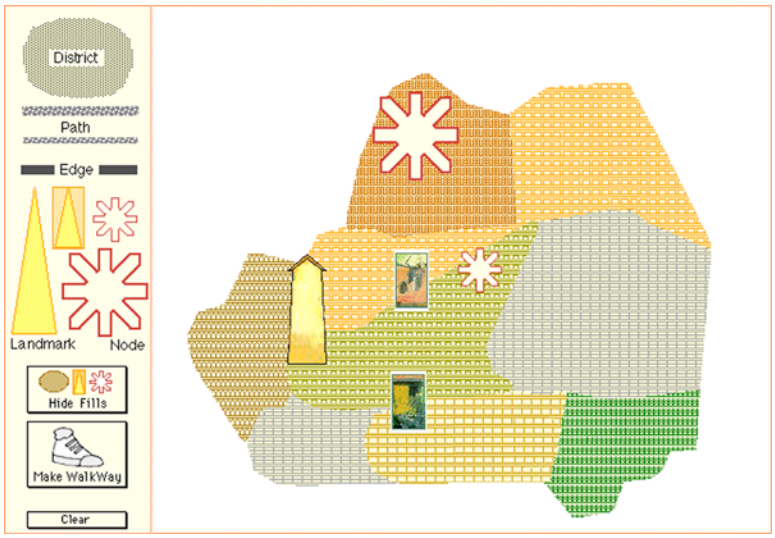


Figure 5. Users can specify characteristics of an image element. Menus associated with the district, landmark, and node symbols enable selections of particular attributes such as scenes and towers.

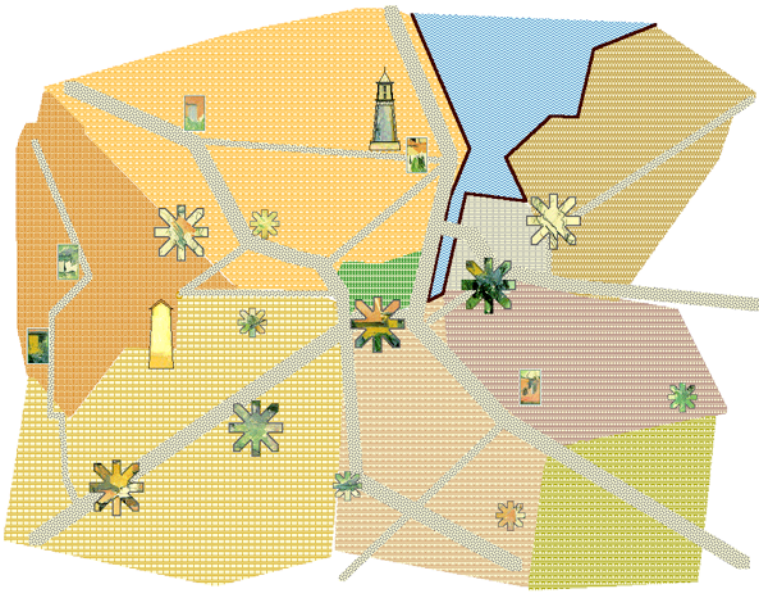
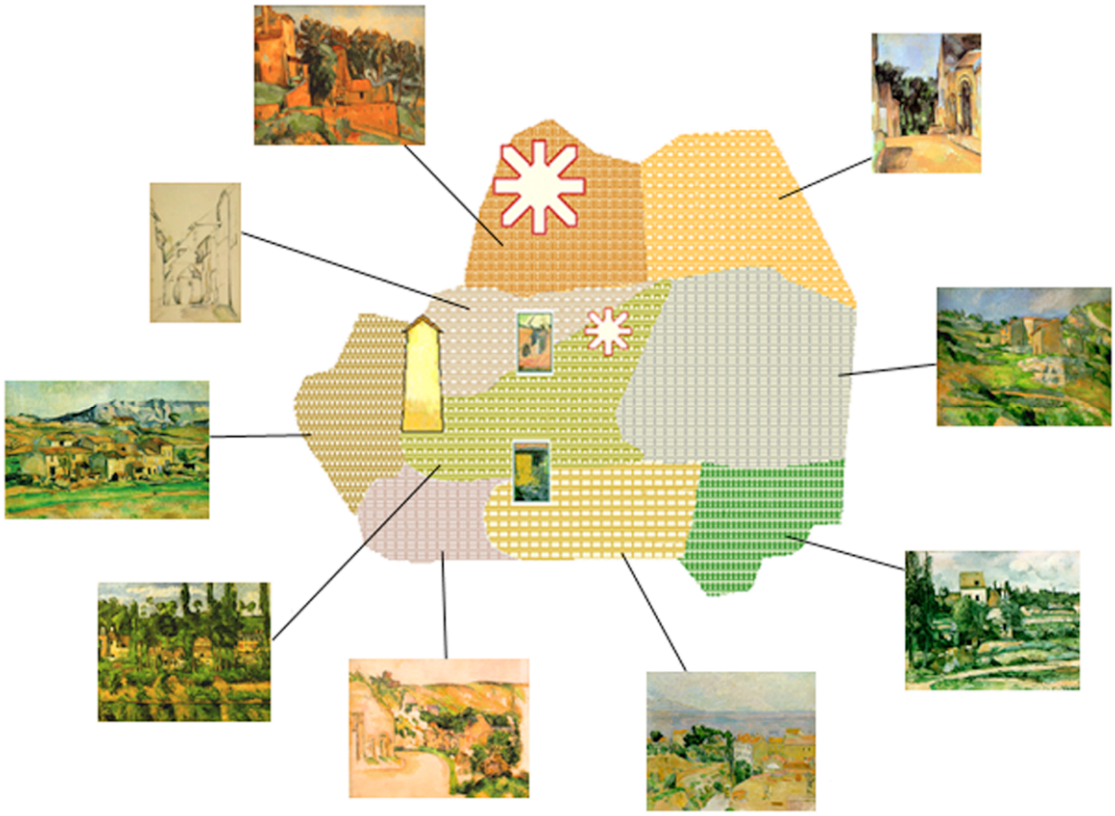


Figure 6. A fully developed layout, including all five elements placed relative to one another. Menu specifications for nodes, landmarks, and districts fill the corresponding symbol with an indication of imagery the software will use in the final walkway sequence.



Painting reproductions are from Machotka, P. (1996). Clockwise, from top right: *Ferme à Montgeroult*, 1898; *Maisons en Provence – le vallon de Riaux près de l'Estaque,* 1882-83; *Le Moulin sur la Couleuvre à Pontoise,* 1881; *Vue sur l'Estaque*, 1882-85; *Route tournante à la Roche-Guyon,* 1885; *Le Château de Médan*, 1879-80; *Haneau à Payennet près Gardanne* (formerly *La Sainte-Victoire, Environs de Gardanne),* 1885-86; *L'Eglise Saint-Pierre à Avon* (formerly *Une rue à Aix)*, 1891-92; *La Maison de Bellevue,* c. 1890.

Figure 7. Reproductions of paintings by Paul Cézanne are the sources of images associated with each district. The software uses excerpts of the paintings to compose street-level scenes for the walk-through.

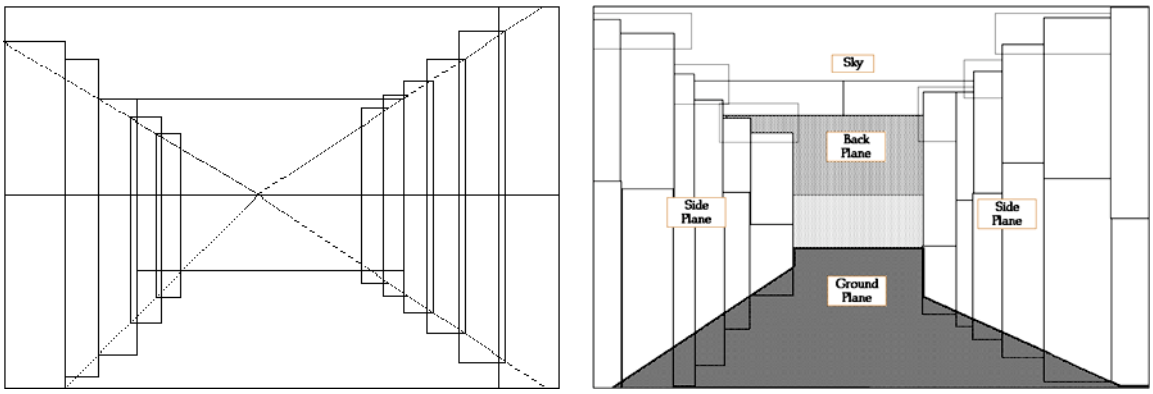


Figure 8. The classic perspective framework consists of a ground plane, sky, and side planes defined by diagonals that converge on a vanishing point along the horizon in the back plane. We use variations of this framework as the basis for automatic compositions of street-level views in the virtual world. Added detail helps to guarantee variety: silhouetted images crown the back plane, and side planes may consist of bases, facades, and roofs.

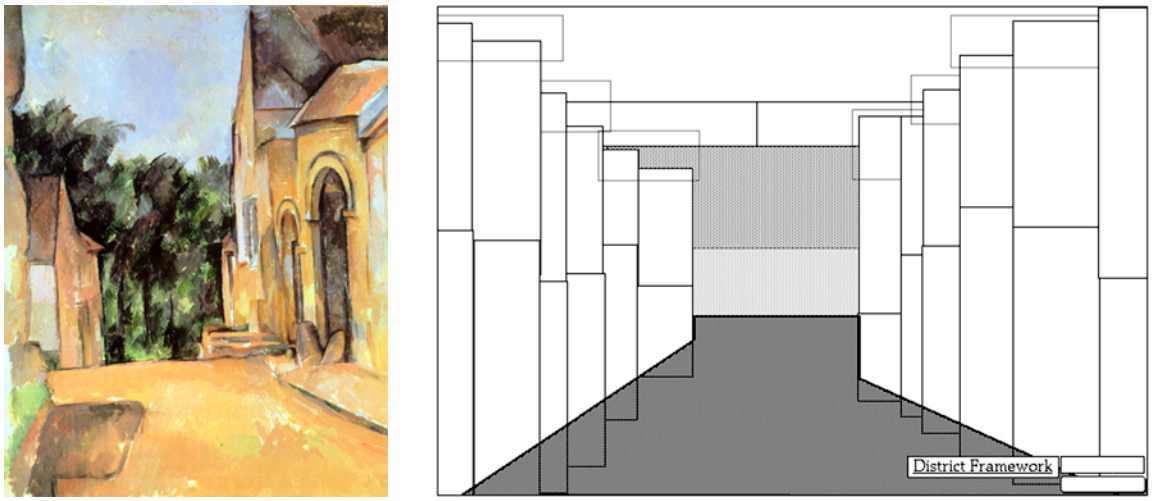


Figure 9. Cézanne's *Ferme à Montgeroult* presents a scene with a certain structural character: the terrain is smooth and relatively flat; each side of the street is covered evenly with buildings; building facades often have distinguishable bases and rooftops. The software represents each component as a set of variable coordinates to be filled with an appropriate excerpt from the painting.

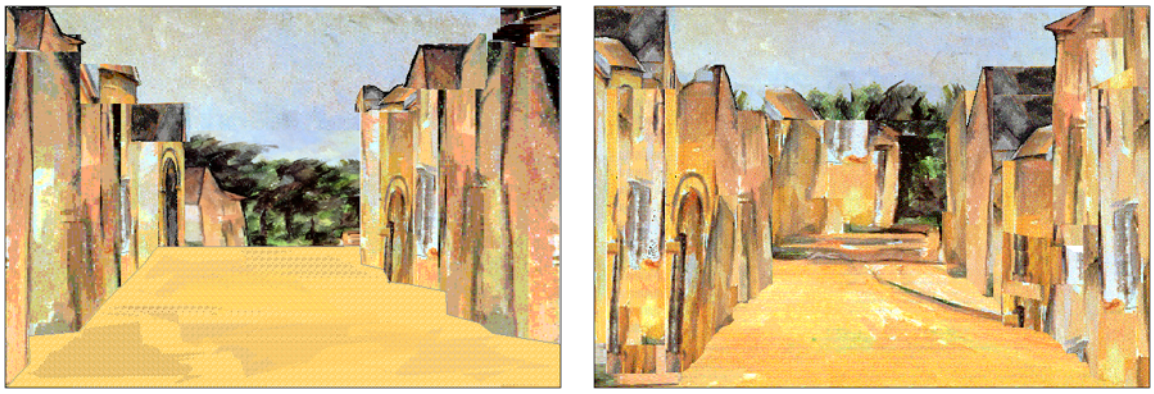


Figure 10. Variations on Cézanne's *Ferme à Montgeroult*. *WayMaker* automatically composes walkway scenes by placing image excerpts within a variation of the painting's structural framework. These two scenes would occur within the same district, maintaining its character while portraying distinct scenes.

Figure 11. Framework analyses of landscape scenes. Each painting suggests certain relationships: panel to panel, top to middle, middle to base, base to ground, back to ground, etc. Differences in these relationships contribute to the richness of a *WayMaker* virtual world.

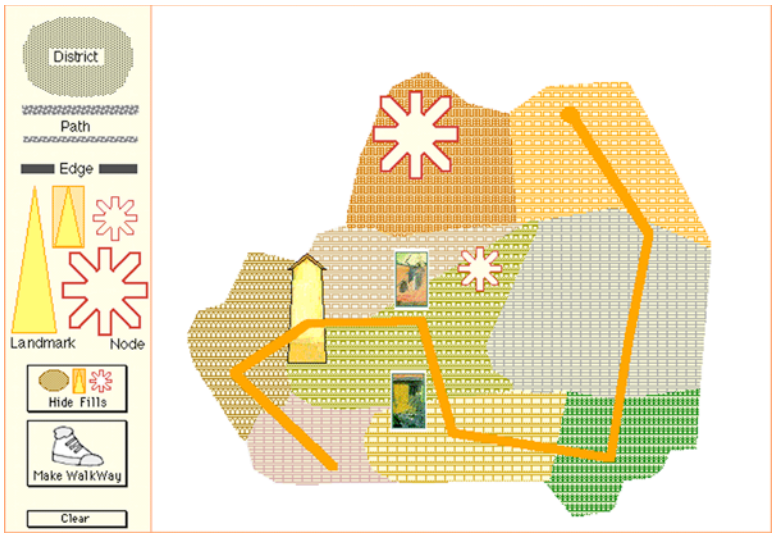
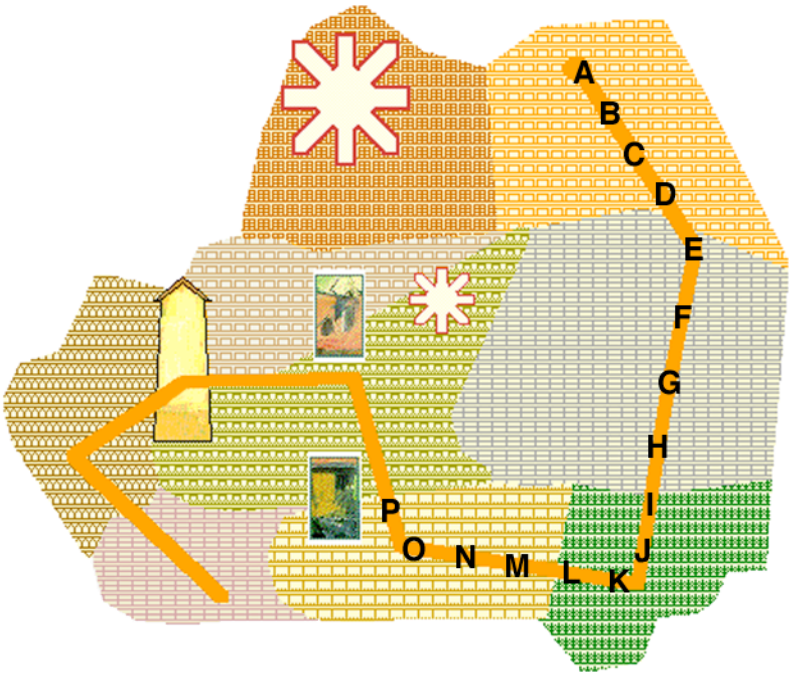


Figure 12. Making a way. The user clicks the sneaker icon to change modes and indicate a walkway through the environment.

Figure 13. Walkway scenes. The user clicks the tip of the walkway ribbon to trigger calculation, assemblage, and display of a corresponding sequence of street-level scenes.

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