# THE LATEST TECHNOLOGIES OF URBAN PLANNING: THE CONTROL OF THE LANDSCAPE AND THE DEVELOPMENT OF THE URBAN ENVIRONMENT THROUGH DIGITAL SURVEYS

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## Abstract

*In recent years, GIS systems have evolved because of technological advancements, which have improved the type of acquisition and allowed to manage multiple amounts of data information simultaneously.*

*Through systems that use active techniques, such as the laser scanner plane, or passive techniques, such as photogrammetry (by aircraft, drones and other down-sensing platforms), one can create a model point cloud displayed with leading CAD and GIS software.*

*Over the past decade, the laser scanner plane (LiDAR) has come to been considered the quickest, most efficient and advantageous tool, providing accurate dense clouds of points and 3D modeling, surface areas and land. Recently, with the photogrammetric technique, thanks to the improvements of the optical sensors and, in particular, to new algorithms (dense image matching), what has emerged is a competitive technology, able to provide, in an automatic way, 3D point clouds and digital surface models geometrically comparable to those obtained with active instrumentation, even for large areas.*

*Such sophisticated equipment captures the data, making it also accessible through the new mobile technologies of communication, capable of operating within the web-based information systems. This paper aims at understanding how the new technologies of digital survey have transformed the field of planning and the multiple use of the information obtained.*

**Key words:** *digital technologies, urban planning, regional planning, GIS, passive sensors, active sensors*

## 1. INTRODUCTION

Computer models and information systems have been used for urban planning and design since the 1950s. Their capacity for analysis and problem-solving has increased substantially since then, with new hardware and software able to manage large amounts of data.

The development of Geographical Information Systems (GIS) from the 1960s onwards has made analysis methods, such as McHarg's map overlaying, more practical and decision making more intuitive (Goodchild 1992; Goodchild and Hening 2004). Progress in the information systems in the 1980s and 1990s had significant impact on urban design and modeling (Batty et al 1998; Liu 2009).

Visualization has improved with the new platforms and has made the transfer of Computer Aided Design (CAD) data into GIS possible, allowing the development of numerous 3-D models (Batty et al 1998). Towards the end of 1990s, GIS had developed into a user-friendly environment, able to link spatial attributes and quantitative data at a fine scale and to produce sophisticated spatial analysis and maps (Batty et al 1998; Moudon 1997).

The early years 2000s brought about better technologies for data visualization and intuitive software products, which are nowadays being used to design and manipulate highly complex urban systems.

In the following, we will show how improvements in computational performance, innovative systems acquisition and dissemination network have greatly boosted the results of reconstruction methods that basically use the same principles.

The network is the enabling factor, it has the potential to move computing into the heart of the planning system for new ways of portraying place, space and information, in short, for communication.

The network and related new information, and the communication technologies are the enabling presences that have the potential to move digital planning away from its traditional characteristics.

## 2. MATERIALS AND METHODS

Tools for producing virtual environments are many and varied. This section explores a range of methods to model existing urban scenes (Hudson- Smith, 2009).

The modeling of such scenes, as a portrayal of the existing environment, is crucial in order to visualize any proposed development in context. However, the modeling of the existing environment is what poses the most difficulty, as Kjems (1999) states. It is much more difficult to build a three-dimensional model of an existing environment than a new development.

The methods examined are based on four levels of detail and abstraction, namely panoramic visualization, prismatic primitive, prismatic with roof detail, and full architectural rendering. We shall begin by examining panoramic visualization.

Panoramic visualization is not three-dimensional per se, in that it consists of a series of photographs or computer rendered views stitched together to create a seamless image. Rigg (2000) defines a panorama as an unusually wide picture that shows at least as much width-ways as the eye is capable of seeing. As such, it provides a greater left-to-right view than what we can actually see (i.e. it shows the content behind you as well as in front). Here we illustrate a sample, Canary Wharf Square in London Docklands (Fig.2.1).



**Fig. 2.1.** Panoramic Image of Canary Wharf Square, London Docklands.

Although panoramic images are two-dimensional, as they are constructed from a series of photographs, the effect is considerable realism (Cohen, 2000). Panoramic images are not a new concept brought about by the rise of the digital age; they have actually been around since the 1840's, with the introduction of the first dedicated panoramic cameras. However, it was not until 1994, with the introduction of the QuickTime Virtual Reality (QTVR) for the Apple Macintosh that panoramic production, based on the stitching of a number of photographs, that is became available on home computers for the first time. QTVR works by taking a sequence of overlapping images, automatically aligning and blending them together to create a seamless panorama.

The resulting picture is a photorealistic capture of a scene taken over the time required to capture the images, typically between 30 seconds and two minutes. Panoramas are viewed online, either via a plug-in or Java applet. The viewer renders a section of scene allowing the user to pan and zoom the panorama, using a combination of the mouse and keyboard. Each single panorama can be defined as a node on the desktop or the net, while hot linking between a series of panoramas creates a multi-nodal tour.

Since the introduction of the QTVR in 1994, a number of rivals have emerged, providing similar stitching and viewing abilities. These rival products compete on various aspects, such as progressive downloading, node jumping efficiency, full up and down viewing, support for sound and foreground animations, and scrolling speed/image quality/file size balance (Merlin, 1998). One such product is Photovista from Live Picture, which is available for both Windows and Macintosh platforms. This has capitalized on the market by providing a powerful stitching algorithm within an easy to use interface.

The image of Canary Wharf Square in Fig. 2.2, displays a considerable amount of distortion when projected on a flat plane. Distortion is a result of the images 360-degree field of view, i.e. the image shows both what is in front of and behind the viewer. Removing distortion requires the image to be mapped onto a shape corresponding to the field of view of the camera. For example, if the camera has a standard 35mm lens, the field of view in portrait position (i.e. with the camera on its side) is 54.42 degrees, creating the equivalent of a ‘cone’ when the resulting panorama is stitched. If the camera uses a wide-angle lens, such as an 8mm fisheye, the subsequent field of view increases to 180 degrees and the resulting image represents a spherical viewpoint as in Fig. 2.2.

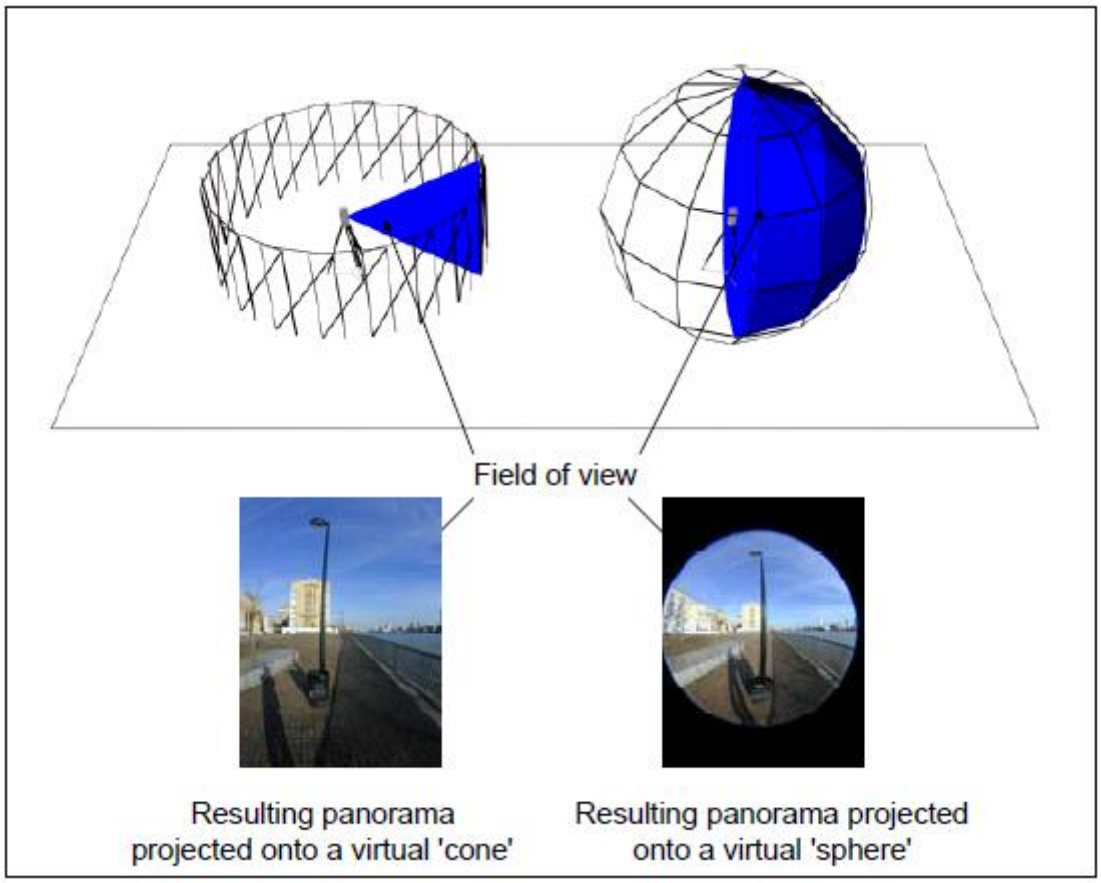



**Fig. 2.2.** Projection of Panorama According to Field of View.

The number of images required to make a panorama depends on lens type and the resulting horizontal field of view (HFOV). To successfully stitch and blend a series of images creating a seamless panorama, an overlap of between 30-50% is required between each image.

The number of images required can be calculated using the following rule of thumb (Rigg, 2000):

- Number of images required = 36000 / (50xHFOV)
- For portrait capture HFOV = 2xtan-1(18/focal length)
- For landscape capture HFOV = 2xtan-1 (12 / focal length)

Fig. 2.3 illustrates a series of images captured, as part of the Hackney Building Exploratory Interactive. The images were taken using a Kodak DC220 digital camera with a 29.00mm lens, resulting in a 63.55-degree field of view. A total of 16 images were captured, to ensure a seamless panorama. As Fig. 2.3 illustrates, a panoramic tripod mount was used to ensure that all the images were captured from a single nodal point. The nodal point is defined as the focal point of the camera lens. The panoramic mount ensures the camera is kept level throughout the capturing process and it also provides precision rotation, allowing the camera to be rotated the required number of increments through 360 degrees.

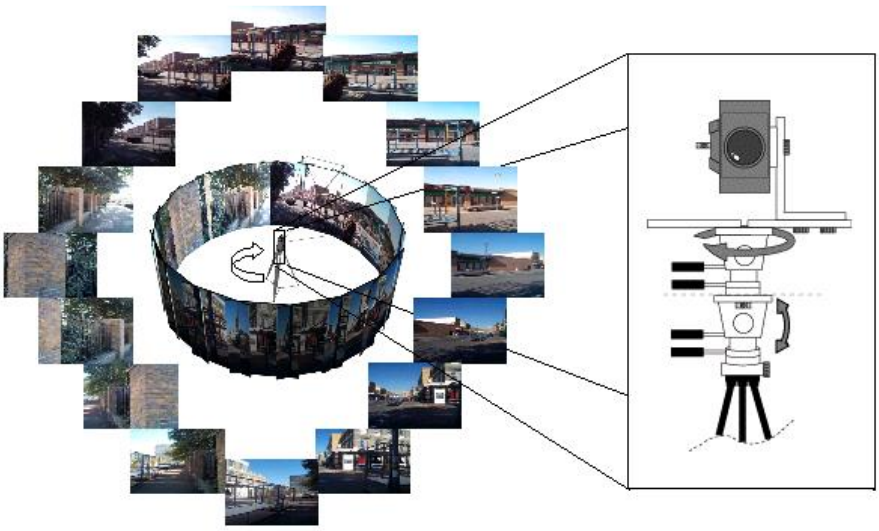


**Fig. 2.3.** Creating a Panoramic Image.

Once captured, the images were loaded into the stitching software, in this case PhotoVista, as seen in Fig. 2.4. The images are aligned, warped and blended to create the final panorama. The panorama can be saved in a range of formats, including the option of Java based viewing for cut and paste insertion into an HTML document.




**Fig. 2.4.** Stitching Images in PhotoVista.

During the capturing process, it is important to bear in mind two factors. Firstly, the exposure of each image needs to be fixed after the first image is captured. This ensures that all the images are captured with the same level of exposure, evening out any changes in light conditions between photographs and ensuring the seamless blending of the resulting panorama. Secondly, it is important to take into account any moving objects in the scene such as people or vehicles.

Fig. 2.4 illustrates a series of images captured over time, such as that of a pedestrian walking within the perimeter of the camera. If the images with the pedestrian are captured in sequence, the sequence will include the pedestrian in multiple photographs. When the resulting panorama is stitched, depending on the pedestrians' position relative to each frame, the pedestrian will feature in varying locations. If the pedestrian is captured in the overlapping sectors of the images, the resulting panorama will contain ghostly figures. This happens when the stitching software is attempting to blend out objects that are not in both overlapping regions. For this reason, pedestrians need to be captured in the center, i.e. in a non-overlapping section of a single image. This ensures that human presence is included in the scene while ruling out multiple instances and ghostly figures. Moving vehicles are more problematic to capture. It is often not possible to capture them in the center of a single image.

Therefore, vehicles either have to be captured while stationary, for example at traffic lights, or from a distance, ensuring they can be aligned in the central region of the image. Capturing people and moving vehicles is a problematic and time consuming process but, nevertheless, it is essential if a scene is to look realistic.

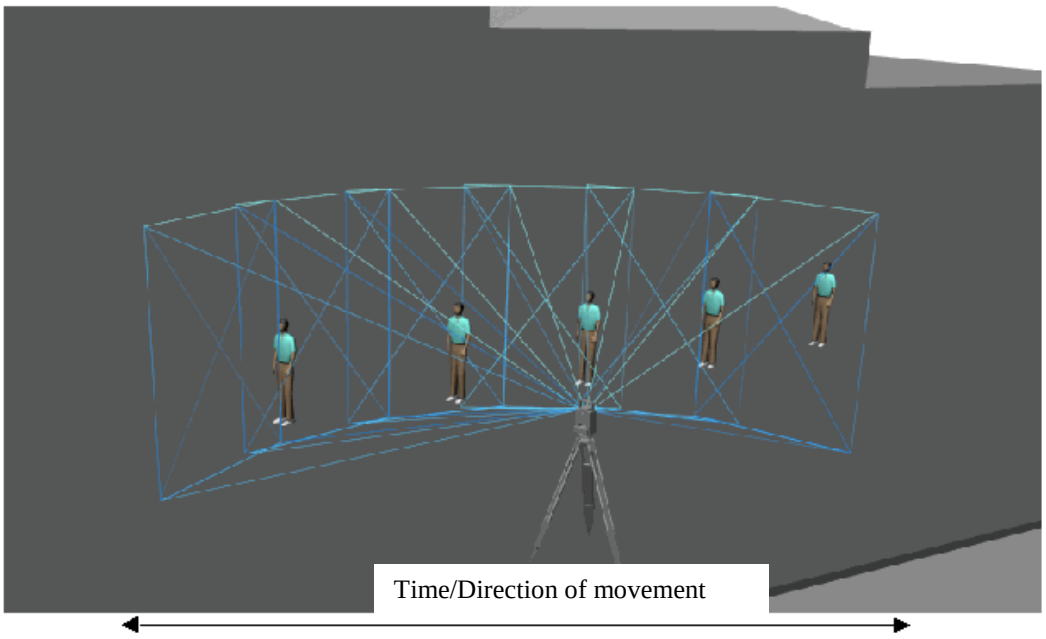



**Fig. 2.5.** Pedestrian Movement During a Panoramic Capture.

As previously stated, a panoramic image is two-dimensional and the user is able to pan and zoom within the scene. But as the scene is composed of a single viewpoint, it cannot convey true spatial perception (Waack, 1998). A person views the real world three dimensionally, viewing the world from both left and right eyes, thus creating two slightly different viewpoints. These, in turn, embody our spatial perception. Fig. 2.6 illustrates such left and right eye views of Canary Wharf, in London's Docklands. Note the differences with respect to the central line.

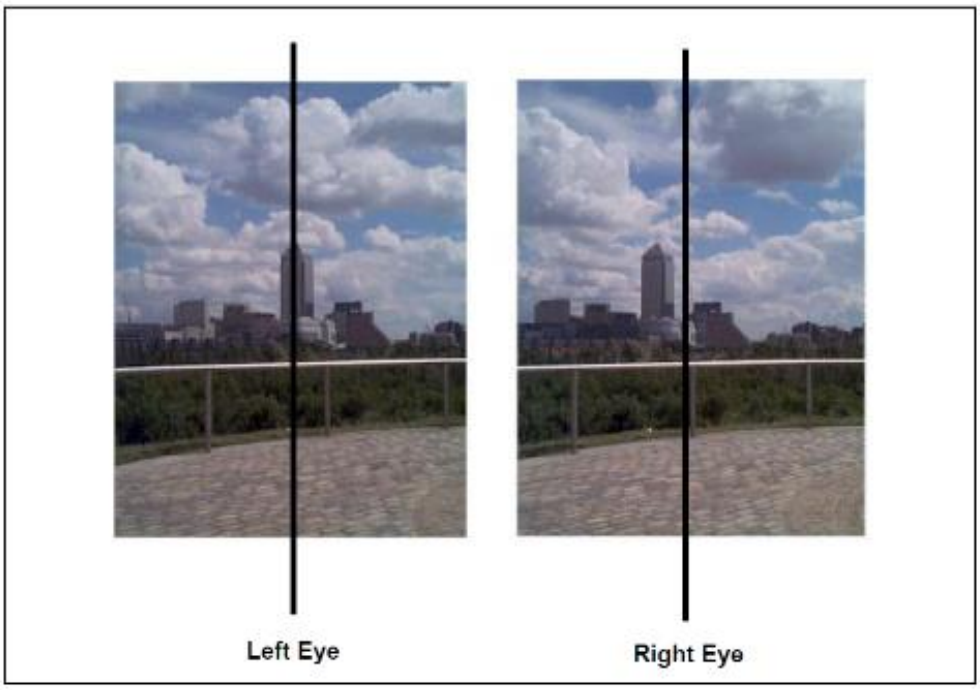



**Fig. 2.6.** Left and Right Eye Views of Canary Wharf, London Docklands.

In order to create the illusion of depth, either in a photograph or rendered scene, the scene needs to contain both left and right eye views, which can be successfully conveyed separately to the brain. This can be achieved by creating an anaglyph representation of the scene. An anaglyph consists of two separate images, merged to create a left and right eye view. In order to convey this to the brain, the images are split into their separate red, blue and green color channels. The left eye view consists solely of the red channel and the right eye of only the blue and green channels (see Figure 2.7). The channels are merged using a standard image manipulation package.

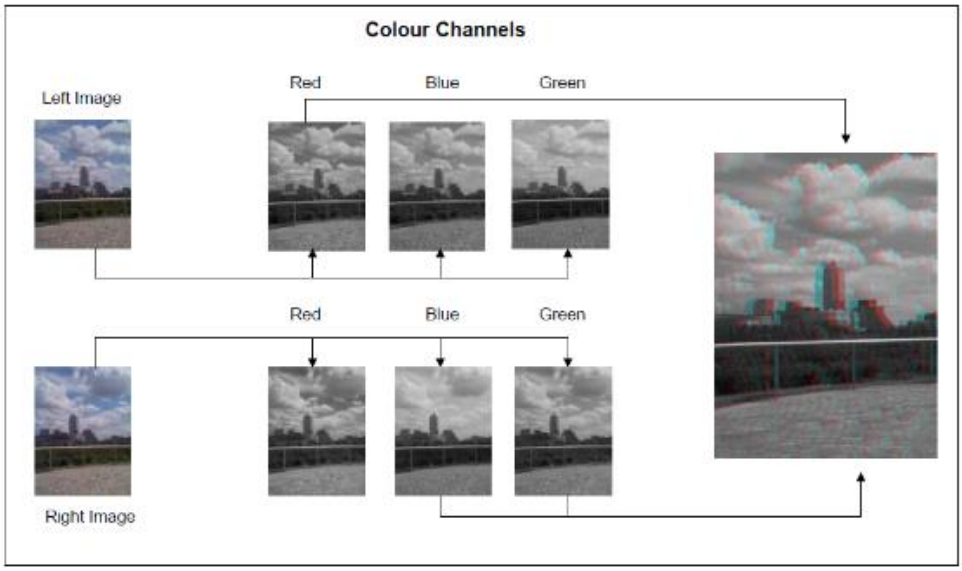



**Fig. 2.7.** Merged Left and Right Images Split into Color Channels and the resulting Anaglyph Image.

Using a pair of anaglyph viewing glasses, with a red color lens for the left eye and blue for the right eye, an illusion of depth can be obtained. The red filter on the left eye extracts only the information of the left view, thus left and right eyes see slightly different images, allowing the perception of depth. Using the concept of anaglyphs, panoramas that include both left and right eye views of the captured scene can be produced, but in order to achieve this, two separate panoramas need to be photographed, each approximately 7 centimeters apart (eye width) as we show in Figure 2.8.

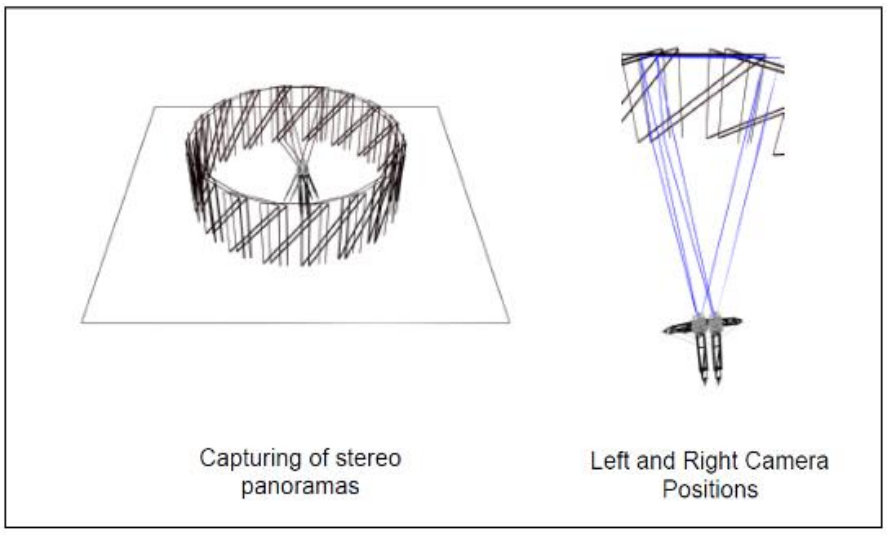



**Fig. 2.8.** Creation of Stereoscopic Panoramas.

Panoramas operate by placing the user in the center of the photograph and rotating the viewpoint around a central axis. A hybrid is the panoramic object movie that effectively places the user to the side of the scene looking inwards, towards the central axis, rather than outwards. A panoramic object is essentially the digital equivalent to a flick book animation with a series of frames captured during which the object is rotated a full 360 degrees.

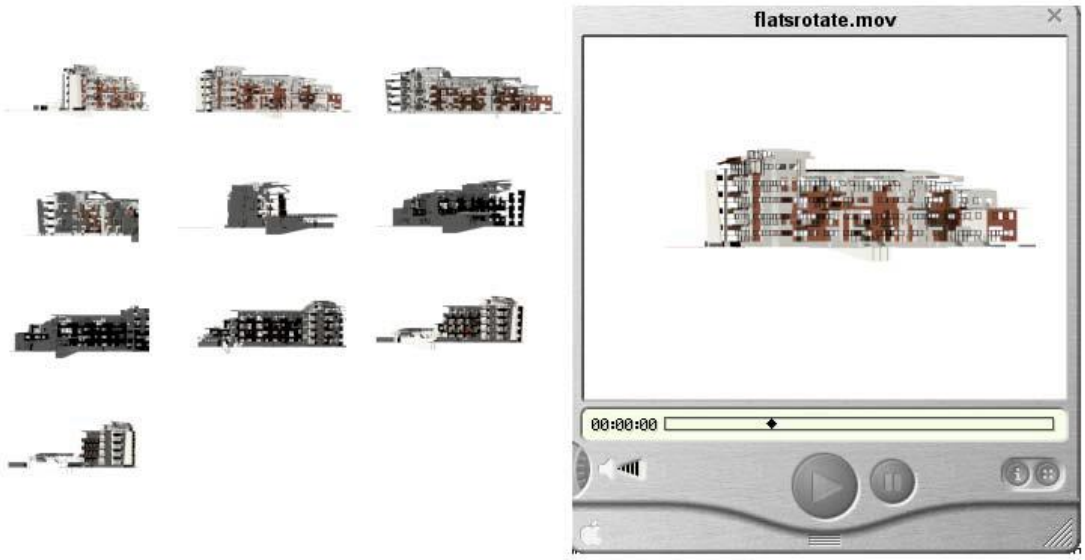



**Fig. 2.9.** QTVR frames and the Resulting Object Movie.

Figure 2.9 illustrates a QTVR rendering of a block of flats used for the digital visualization of the Bridge Lane Planning Inquiry. The figure shows the frames rendered to create a QTVR scene and the resulting movie. A total of 10 frames were rendered and each is played back as the user moves the mouse over the scene, creating the illusion of rotating the object.

In terms of Brutzman's (1997) components, panoramas score highly with respect to the use of available bandwidth and file size. To view and navigate a panoramic image, all that is required is a plugin or JAVA applet and the image file. Based on a medium level of compression, image file size for a typical panoramic scene can be as little as 150k or 200k including the JAVA viewing applet. Capture techniques are both rapid and low cost. Panoramic images are thus well suited for the communication of existing locations via the Internet, allowing low file sized photorealistic representations. However, interaction is limited, for all users can do is pan and zoom or link to the HTML documents. The image is two-dimensional, so no higher level of interaction is possible. The use of panoramas thus becomes more problematic if new developments are to be visualized. This involves integrating a three-dimensional object with an existing panorama or creating a rendered photomontage, essentially augmenting reality.

For the production of full three-dimensional models of the existing built environment, there are three critical factors - building footprints, roof morphology, and height data. It is the combination of these factors that allows the creation of realistic models. Average height data can be purchased off-the-shelf from mapping companies. This data provides the average height according to building footprints.

Comprehensive data can be obtained from a range of imaging methods, the most widely used being Light Detection and Ranging (LIDAR). LIDAR provides a high-resolution three-dimensional surface, which can be imported into a GIS and draped with an aerial photograph as shown in Figure 2.10.



**Fig. 2.10.** LIDAR-Based City Models http://www.globalgeodata.com/bldgdata.html

LIDAR is at the high end of the data range scale and as such is not suitable for the production of models aimed at online distribution, although combined with building footprints, average height can be extracted from such datasets.

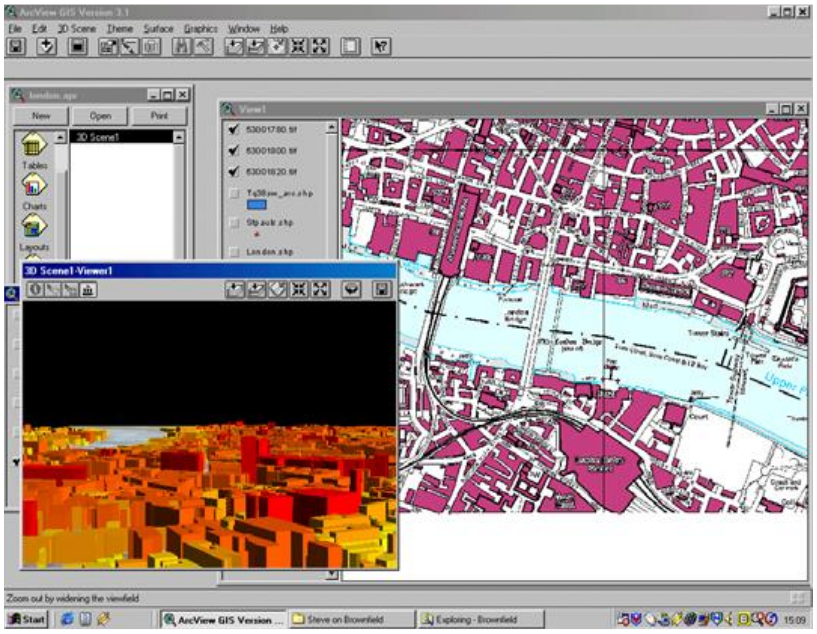


**Fig. 2.11.** Extrusion by Average Height Derived from LIDAR in ArcView.

Figure 2.11 illustrates a section of Central London, extruded from building footprints up to an average height derived from the LIDAR data.

The resulting model is a prismatic representation of Central London, but it is both crude and unwieldy in terms of required processing power and file size. Manageability of the model can be improved, but that would require a considerable generalization of the base data.

Prismatic models lack any significant architectural detail and thus do not convey any compelling sense of the nature of the environment (Batty, Smith et al., 2002). Roof morphology can be added, either with a GIS or via a standard modeling package such as Microstation or 3D Studio. Over the past years, there have been considerable research efforts into developing the capabilities of the GIS, in order to handle three-dimensional information of the built environment (Faust, 1995). This has often been achieved through the linkage of CAD technologies to a GIS database (Ligget, Friedman and Jepson, 1995), but such linking of GIS to CAD is a tentative and cumbersome process.

Figure 2.12 illustrates the output of PAVAN, a three-dimensional modeling package for the MapInfo GIS package.

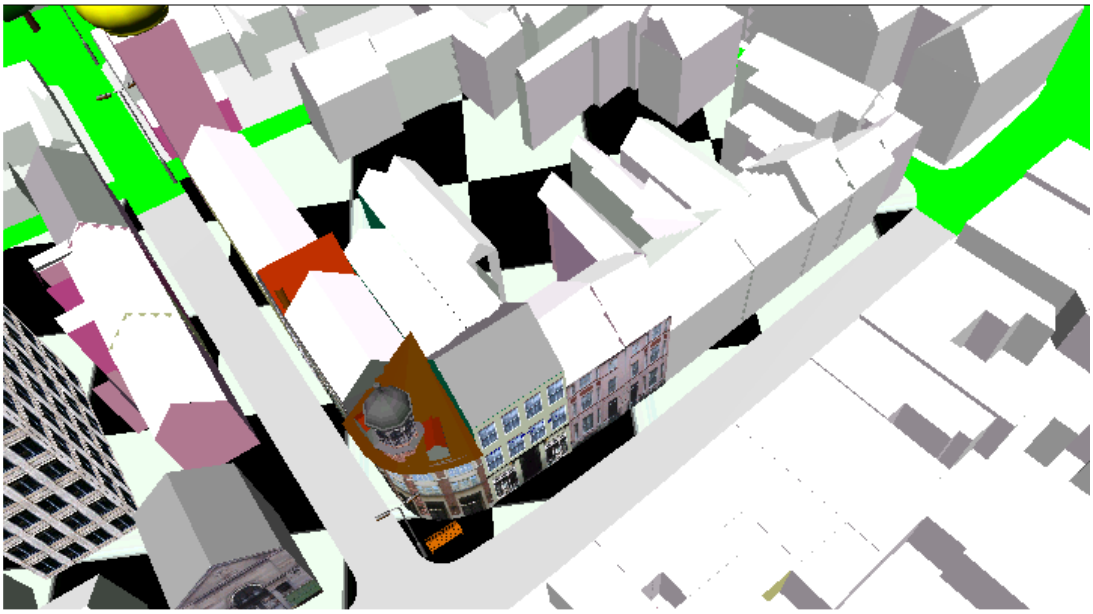


**Fig. 2.12.** PAVAN Output from MapInfo, Illustrating Roof Morphology.

PAVAN enables roof morphology and texture maps to be added to height extrusion up to eye level. While this is adequate for basic modeling, the level of realism is low and it relies on the knowledge of the modeled area's roof structure data, which is not commonly available without a comprehensive area survey. Where the roofing morphology is not known, new methods for modeling are required.

Methods that rapidly extract and texture maps, of both building outlines and roof morphology, have become readily available in the last 18 months. A result of the increase in personal computing power and the demand for realism, predominantly in gaming environments, packages such as *Canoma* from Metacreations, *GeoMetra* from AEA Technologies and *Image Modeler* from RealViz have been developed. These packages are aimed at creating models, which are optimized in terms of file size, while retaining a high degree of realism and are directly suited for the production of models aimed for on-line distribution.

The following discussion provides an illustrative walk-through of the process of creating a texture mapped three-dimensional model of a typical new building development in the UK using Canoma.

Canoma is typical of the new range of low cost photogrammetric modeling packages. The model was constructed from two photographs, taken with a Nikon CoolPix 850 digital camera and these are shown in the top line of Figure 2.13.



**Fig. 2.13.** Canoma Modeling Stage 1.

The model was constructed from two photographs, taken with a Nikon CoolPix 850 digital camera and these are shown in the top line of Figure 2.13. The photographs were framed to ensure that all four corners and any shared geometric features of the building were in view. The first stage in constructing the model is an intuitive division of the building into a series of primitives, these primitives are then aligned, joined and stacked to create a wireframe version of the building. Once the building has been divided into basic shapes, the first primitive can be placed - in this case a box, which constitutes the main area of the building, shown in the second line of Figure 2.13.

The correct placement of the first primitive is all-important. From the first primitive, Canoma calculates the location of the ground plane and the camera position. Pinning the corners to the corresponding points in each photograph anchors the box, the pins being represented as red triangles in Figure 2.14. Where a corner is not visible, as is the case in the bottom right photograph, a bead or a round red dot is placed to guide the primitive to approximately the correct position.



**Fig. 2.14.** Canoma Modeling Stage 2.

Stage 2 creates the central roof structure. By using a 'stack' command, the selected roof shape primitive can be placed directly on top of the first box. A combination of pins and beads are then used to align the primitive with the actual photographs, as shown in Figure 2.14.

The third stage repeats the procedure of creating the first box primitive and stacking to generate the front section of the house. To ensure the new section of the model is correctly aligned, it is 'glued' to the first box primitive. The ‘glue’ is represented as the red circle in Figure 2.15.

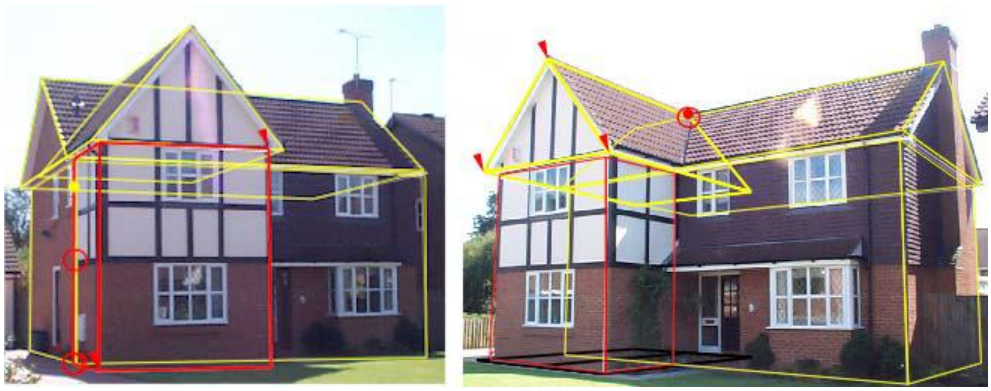


**Fig. 2.15.** Canoma Modeling Stage 3.

The wireframe is now taking shape. Matching the two photographs, the front porch section and chimney are added in the same manner as in stages 2 and 3, using a combination of pins, beads and glue, as illustrated in Figure 2.16.



**Fig. 2.16.** Canoma Modeling Stage 4.

The model can now be automatically texture-mapped and exported in the desired distribution file format. The example provided is for a single building, where two images are sufficient to create the three-dimensional model. Two images are sufficient for the wire frame, as there are a number of linked geometric reference points in each image, thus the model can be made up of basic standard primitives. For more complicated, larger-scale urban areas, the addition of oblique aerial photography is required in order to provide an overview of the entire scene. Combined with street level views, urban scenes can be constructed, as seen in Figure 2.17, which illustrates a model of the Canary Wharf modeled with *Canoma*.

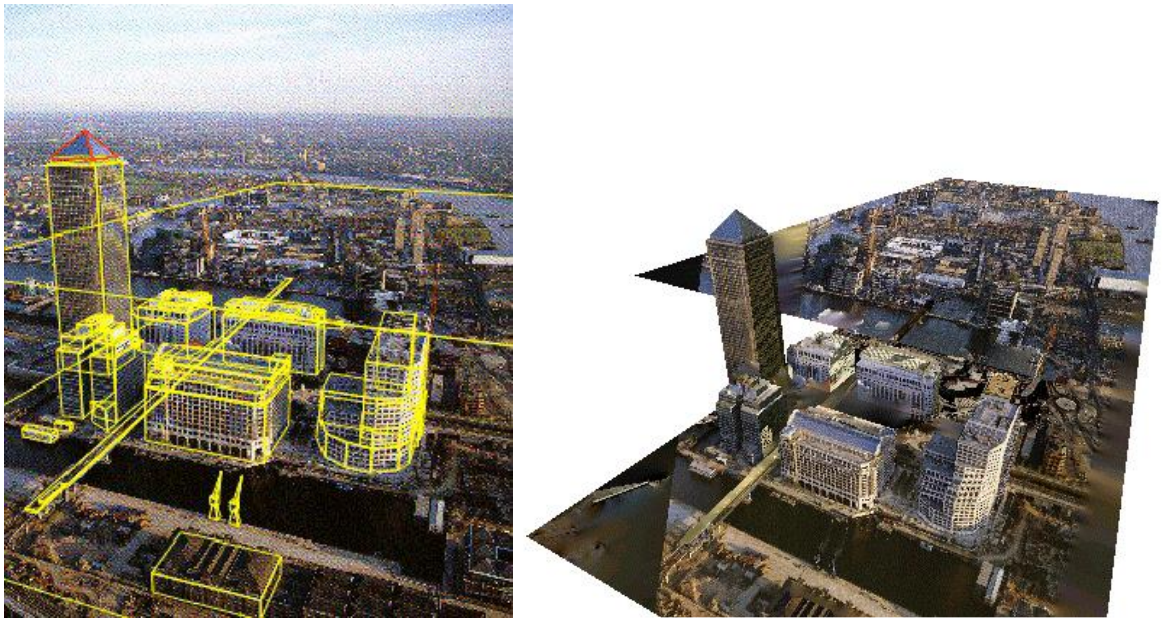


**Fig. 2.17.** Canary Wharf Modeled in Canoma.

This model was produced using a combination of aerial photography and street level photographs taken from the Canary Wharf Square, panoramic example in Figure 5.4. Once a scene is constructed, the file format it is saved in and the resulting format used for distribution are very important for its successful placement online. The format chosen is a critical factor in the balance of Brutzman's (1997) components for networked three-dimensional graphics.

## 3. RESULTS AND DISCUSSIONS

We described the main methods of modeling with the corresponding display of outcome that can be achieved. Geometrically complex buildings can be modeled and textured with the use of photographs. The simple geometry, by underpinning the models, appears architecturally rich. This has allowed small sized models to be produced, in an output compatible with a number of Internet visualization packages, thus meeting Brutzman's (1997) criteria.

This is useful for many different purposes but, above all, it is easy to see how suitable it is for urban and regional planning. Furthermore, the tools and software used allow the accessibility of various format input and output.

In cases such as with the use of software like Canoma and the related photogrammetry software, which are suited for small area local scenes, this is very important. In order to construct the 3D model, the site can be split up into sections with each section modeled, texture mapped, and exported separately before being re-imported and, through special arrangements, ensuring a perfect fusion for each scene. The end result was a photorealistic scene.

## 4. CONCLUSIONS

Conclusions in such a field as this one are often difficult to draw, as the technology behind it is constantly changing. The level of interaction and what it is now possible to communicate over the web has changed almost beyond recognition.

In this paper, it was important to highlight that the reconstruction methodology has remained the same but technological changes have allowed to obtain the best result in terms of capacity and performance.

Although, the key for the digital planning is not the computer as such but the network. It is the rise of the web that first led to the introduction of the notion of Online Planning, and it is the technologies that have evolved for their use over the network, which, in turn, have allowed the research to generate the level of success it has had. Without the network, planning with computers is restricted to stand-alone machines and the traditional planning/architecture software.

Once the network was introduced, new and innovative software became available, as well as the obvious benefits of distributed communication. The distributed communication and the potential it holds for participation could reshape the planning system. The concept is simple and such platforms allow people to have a free and open say in any developments, be they local, national or global.

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