Web Based Public Participation in Visual Impact Assessment of Urban Landscape

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ABSTRACT

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Web Based Public Participation in Visual Impact Assessment of Urban Landscape

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In the theoretical aspect of the landscape assessment, there have existed two separate approaches. One is the inventory approach; the other is the public preference model. Based on different assumptions, the methodologies of both also show differences. Although they have been proven effective in natural landscape assessment, when it comes to urban landscape assessment, neither of them can be viewed as reliable. The urban landscape may be normally designed and planned by professionals. However, it is for public use. Here, the urban landscape assessment and management can be viewed as the interactions between the professional, public and the urban landscape itself. The term "professional" specifically refers to those who design and plan the urban landscape. Based on the analysis of the urban landscape characteristics, and the relationship between the professional and the public, this thesis incorporates the three of them into the assessment and management of urban landscape. The technical aspect of urban landscape management, visual impact assessment of urban landscape, is introduced and analyzed specifically on the basis of the information inventory and public participation. The weakness of the traditional method of public participation is exposed. A specific Web based public participation visual impact assessment system is proposed to integrate both approaches. The specifications for such a system are examined. They aim to mitigate the weakness of the traditional method, and act as the norms for the system design. The possibility of developing such a system is analyzed, followed by a detailed consideration of its design. Finally, a prototype system and pilot study are introduced. They expose the potential of constructing such a virtual platform on the Internet, which can empower the public to participate in the urban landscape assessment and management process more actively and facilitate the collaboration between the professionals and public in the process.

摘　　要

在景观评估的理论研究方面，一直存在着两个分离的方向。一种是景观信息描述的方法，另外一种是公众喜好模型。基于不同的理论假设，两者在研究方法上有很大的差异。虽然他们各自在对自然景观的评估上都被证明是有效的，但对于城市景观的评估，两者都难以被认为是可靠的方法。一般而言，城市景观是有景观建筑和规划领域内的专业人士来设计的。但，他们的设计又是用以服务于大众的。在此，城市景观评价和管理可以被看作是专业景观建筑设计师，公众和城市景观三者之间的一种互动。基于对城市景观特点，专业人士与公众的关系的分析基础之上，本文将这三者都包含入城市景观的评估和管理之中。城市景观评估的一个重要技术方面—视觉影响分析，被详细介绍。并且在景观信息描述和公众喜好两个方面对这一方法目前存在的不足加以探讨。本文试图通过设计一个基于互连网的城市景观视觉影响分析系统来弥补传统公众方法的不足。该系统也将上述两种方法统一起来。本文将会详细讨论此系统的可行性和设计规范。一个实验性原型系统用以展示建立一个基于互连网的城市景观评估平台的前景。它也为在未来城市景观规划和管理中景观建筑师和公众建立新型合作关系提供前景和基础。

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CHAPTER ONE

INTRODUCTION

The fast development of society accelerates the transformation of urban landscape. As an important component of society and environment, the urban landscape's visual quality is attracting people's attention. To satisfy people's appreciation for high quality urban landscape, urban planners try to improve the visual sustainability in urban landscape and maintain valuable natural landscape resources with high visual quality in urban space (Oh, 1994). Urban visual landscape assessment includes three major problems: the theoretical problem of how to evaluate scenic beauty, the administrative problem of how to integrate visual aspects in the planning process (Lange, 1994); and the technical problem of how to visualize possible changes in the landscape. In the past, research has emphasized the analysis of people's perception of natural landscape and the amenity assessment of it (Wherrett, 1996a). The urban landscape assessment, and one of its basic technical aspects, the visual impact assessment, has been overshadowed.

1.1 Landscape and landscape assessment

The term "landscape" commonly refers to the appearance of the land, including its shape, texture, and colors. It also reflects the way in which these various components combine to create specific patterns and pictures that are distinctive to particular localities (ITATLI, 1995). The landscape is not a purely visual phenomenon; it relies heavily on other influences for its character. These include the underlying geology and soils, the topography, archaeology, local history, land use, land management, ecology, architecture and cultural associations, all of which can influence the ways in which landscape is experienced and valued.

In the domain of landscape assessment, there exists a dichotomy between the descriptive inventory approach and the public preference model. The former is often utilized by professionals, while the latter wants public participation.

1.1.1 The descriptive inventory approach

Descriptive inventories comprise the largest category of techniques for assessing scenic resources; they include both quantitative and qualitative methods of evaluating landscapes by analyzing and describing their components (Arthur et al, 1977).

Traditionally, the researcher inventories the landscape according to various factors. Examples include landform elements (Land Use Consultants, 1971), landscape patterns or themes (Hammitt et al, 1994; Linton, 1968), landscape character (Crofts, 1975), landscape qualities (Palmer, 1983), dimensions (Propst and Buhyoff, 1980) and the landscape preference predictors (Hammitt et al, 1994; Brush and Shafer, 1975). The landform elements are often determined by the terrain of the research domain. Landscape themes refer to the land use. The landscape quality is often abstracted into a regression equation, which relates the landscape amenity to landscape physical attributes or subjective variables. The dimensions are the selected variables in the equation. For example, they can be foreground vegetation, mountains, man-made features, visible distant landforms, green colours, blue colours, unobstructed expanse of view, clouds, and undisturbed forest (Propst and Buhyoff, 1980).

Scenic elements (such as landform and visual effects), vegetative patterns and so forth, are first identified then described or rated (Arthur et al, 1977). The ratings are primarily based on traditional values within the landscape architecture profession (Palmer, 1983). These methods of landscape evaluation can provide general assessments of landscape quality and a landscape inventory based on subjectively-selected but objectively-applied criteria. Nevertheless, the objectivity of their application, and their precise, often quantitative, results disguise their underlying subjectivity (Crofts and Cooke, 1974).

The descriptive inventory approach contains several assumptions. One is that the value of a landscape can be explained in terms of the values of its components. Another is that scenic beauty is embedded in the landscape components, that it is a physical attribute of the landscape. However, scenic beauty depends on the observer as well as that which is being observed (Arthur et al, 1977).

Actually, the inventory approach can be defined as an interaction between the professional and the urban landscape. This process can be diagramed as in Figure 1.1.

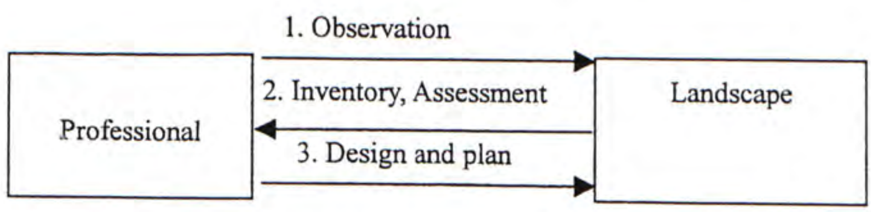


Figure 1.1 Descriptive inventory

1.1.2 Public preference models

The recent upsurge in public interest in preserving the beauty of public lands has resulted in development of scenic assessment based on public input (Arthur et al, 1977). Indeed, it can be argued that the best source of data for such a subjective issue as landscape quality is the general public. Although planners may claim that it is their duty to guide public taste in these matters, the visual attractiveness of the landscape is ultimately a product of the aggregated opinions of all the individuals concerned with that landscape (Briggs and France, 1980).

The visual quality of a landscape is rated on the basis of an observer's individual preference of the whole landscape. Those techniques that are based on subjective assessments of scenery and attempt to encompass the diverse and changing perceptions of individuals are likely to be most successful. The essence of the preference approach is the judgment of the landscape in totality, as opposed to the measurement techniques, which rely on the definition of factors to explain variation in landscape quality (Dunn, 1976).

Questionnaires or verbal surveys are the most commonly used nonquantitative method for sampling scenic preference of various groups. Alternative to questionnaires, one can provide visual stimuli for evaluation, such as photographs (e.g. Shuttleworth, 1980a; Wade, 1982) or one can use other stimuli, such as sound (Anderson et al, 1983). Although perceptions still vary, the variation is less than with verbal descriptions.

The public preference model often includes professionals, the public, and the landscape in the landscape assessment. Ultimately, the assessment aims to provide indications to enhance the landscape resources management, landscape design and planning. This kind of interaction can be diagramed as in Figure 1.2.

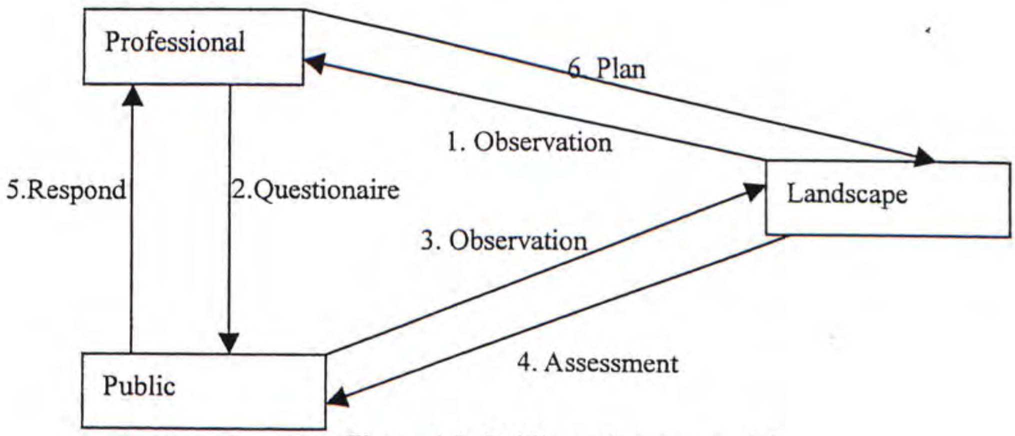


Figure 1.2: Public preference model

There are various difficulties when carrying out such evaluations. Past studies show that the observers' personalities, socio-economic profiles, and locations affect what they observe, as does the duration of the observation and the physical characteristics of the landscape (Hull and Stewart, 1992). There is concern about the ecological validity of photo-based assessments due to differences between on-site and photo-based contexts. Furthermore, it is at best uncertain that the individual rater, rather than the group average, is the more appropriate unite of analysis for tests of validity of basis. The assessment's quantitative or semi-quantitative results are invariably questionable. In order to be representative of society's views, they require extensive, time-consuming surveys (Crofts and Cooke, 1974).

1.2 Urban landscape

Until now, the both the inventory approach and the public preference model are under widespread study. The research object is mainly concentrated on the natural landscape. However, the rapid industrialization and urbanism have been an undeniable fact. The situation is even worse in those fast developing countries or areas, such as mainland China or Hong Kong. More and more people crowd into cities. At the same time, the limited natural resources in urban areas are faced with great threat of destruction. Even though in many countries the related environmental impact assessment, especially the visual impact assessment, must be carried out before the construction of new development, there is still great requirement for more systematic management of the urban landscape resources.

The quantitative method utilizing the regression equation shows validity in many natural landscape assessments. However, there are great differences between the natural landscape and the urban one in perception, which often invalidate the well-developed quantitative assessment method by regression.

The urban landscape can be characterized by the following aspects:

- The complexity is greater than natural landscape; it comprises both the natural and man made landscape components;
- The professional research mainly focuses on the urban landscape resources management;
- The research on the public perception of the urban landscape amenity is still insufficient.
- The interaction between the landscape and the viewer often exists in the views and

view corridors.

The urban landscape assessment is highly related to the urban visual resources management and the project management, especially the environmental assessment. The current work is mainly focused on the protection or improvement of the original amenity of the urban landscape from the new development through visual impact assessment. This can be viewed as an important technical part of the urban landscape management.

Kevin Lynch (1960) exposed the public perception of the urban landscape in his book *The Image of the City*. He stated that the contents of the city images so far studied, which are referable to physical forms, can conveniently be classified into five types of elements: paths, edges, districts, nodes, and landmarks. He also inventories the urban landscape components according to public perception. Which bridges the above landscape evaluation approaches in the imagebility of urban landscape.

Lynch's theory is to view the public perception of the urban landscape from a professional viewpoint. Although clarity or legibility is by no means the only important property of a beautiful city, it is of special importance when considering environments at the urban scale of size, time, and complexity. A good environmental image gives its possessors an important sense of emotional security. One can establish a harmonious relationship between oneself and the outside world. This is obverse of the fear that comes with disorientation.

The special aspects of the urban landscape components in China, Hong Kong or some other Asian areas require more reliable and interactive measures on the urban landscape resources management and assessment, to develop the city landscape in a sustainable mode.

The urban landscape resource management relates not only to the landscape components themselves, but also the viewers. The amenity of the urban landscape can not only be determined by professional design. Public evaluation also plays an important role. The descriptive inventory approach and the public preference models can not be utilized to predict or manage the urban landscape resources separately. The professional design may have to involve public taste in assessing the amenity of urban landscape when coming to some public high concerned projects. The general public, however, lacks the formal training and the authority to shape their own city. The descriptive inventory and the public preference should be incorporated to aid the assessment and the management of the urban landscape.

1.3 Relationship between professionals and the public

The urban landscape itself cannot indicate what the public prefers. In the urban planning process, the public often acts as reviewers of the visual impacts, which are predicted by professionals. The public can attend the community meetings, and answer surveys or questionnaires. However, the interrelationship between the professional and public in the urban landscape planning can not be simplified as performer and audience; there exist more complicated inherent conflicts and collaboration between them. This constitutes the administrative part of urban landscape management.

1.3.1 Inherent conflicts

Efforts at urban visual impact assessment sometimes run counter to an older tradition of architecture and urban design. In that tradition, design is considered the province of an artistic elite. Members of the elite draw on personal aesthetic systems for design principles and may interpret public opposition to their designs as symptomatic of society's long-standing failure to understand advanced art. Practitioners who would assess the visual impacts of the designers' projects may be seen as on the side of the Philistines.

1.3.2 Roles of both sides

Two fundamentally different approaches to evaluation can be distinguished: one, a professional based approach, in which the evaluation is carried out by an expert or a group of experts; the other, a publicly based approach, in which the evaluation is carried out by a number of lay people representing the public or different social groups (Lange 1994).

Professionals in the field of design and environmental planning are seen to have a more sensitive appreciation of landscape quality and are also thought to be able to articulate their feelings more expressively (Dearden, 1981). Citizen interest is thought by some to be lacking in landscape evaluations because of the inherently subjective and somewhat intangible nature of the problem. However researchers who have consulted the public in landscape assessment have found them to he highly motivated, interested in the topic and willing to donate their time irrespective of social, economic and educational backgrounds (Dearden, 1981).

As a planning process concerned with public perceptions, urban landscape visual assessment wants public participation. For natural resource managers to plan for a healthier environment, and to elicit public and political support for such plans, two needs have been identified: (1) to predict the response of various public groups to changes in the environment, for some of whom the visual impact may be a dominant factor, and to plan to minimize any negative impacts; (2) to communicate the effects of proposed changes to other agencies and public review groups to facilitate decision making (Orland, 1994). The empowerment of public participation in the planning process is often diagrammed as a ladder. The degrees of public involvement in environmental decision making ascend through: the public's basic right to know; actively informing the public; public participation in defining interests, actors, and agenda; public participation in assessing risks and recommending solutions; public participation in final decision-making (Kingston, 1998).

1.3.3 Collaboration between professionals and the public

'The initial desire for more information has led to a second demand: meaningful dialogue (communication) between the public and the government where the public has an opportunity to shape decisions." (Susskind, 1994)

Both professionals and the public have to climb the ladder of public participation. There may be trouble when one of the groups is not at the same level of as the other. When the professionals are on "the partnership level" and the public is on the "consultation level", things may go wrong and there may be many difficulties in finishing the project. One will always think that the other is manipulating him.

A professional has to design an environment for everybody, but during the planning process he is in contact with a group, a very special group, which is interested in that particular spare-time activity participation. This special group maybe has too big an influence on the final design (MeighÖrner, 1983).

Fyson (1983) viewed the essence of the kind of education most suited to the needs of both planning and issue-based environment studies follows "*question asking*" rather than "*answer giving*" patterns. "It involves dialogue between the planners and the planned, and opens the way for learning by both sides, i.e. mutual education" (Fyson, 1983).

Even though the urban environment is designed by professional, it is for the public's use. The complexity of the urban landscape requires the advantage of both the descriptive inventory approach and public preference models; both have proved effective in natural landscape assessment. Thus I included both the landscape and viewer into the assessment process. There exist inherent conflicts between the professional and the general public. However, the planning process requires them to collaborate with each other.

Public participation in urban landscape planning typically rests on several assumptions:

- The scenic beauty is embedded in the landscape components, which are physical attributes of the landscape.
- The visual attractiveness of the landscape is ultimately a product of the aggregated opinions of all individuals concerned with that landscape.
- The degradation or enhancement due to the visual impacts of the proposed development is the key issue to be identified.

The first assumption is the theoretical basis for the system to inventory the urban landscape in a database. The second assumption highlights the public participation in urban landscape planning and management. The third one stresses the standpoint that the proposed urban landscape planning support system should address visual impact assessment of urban landscape.

CHAPTER TWO

VISUAL IMPACT ASSESSMENT

2.1 The needs for visual impact assessment

Landscape impacts are changes in the fabric, character and quality of the landscape as a result of development. They are concerned with direct impacts upon specific landscape elements, more subtle effects upon the overall pattern of elements that gives rise to landscape character and regional and local distinctiveness, and impacts upon acknowledged special interests or values such as designated landscape, conservation sites and culture associations.

Visual impacts are a subset of landscape impacts. They are concerned with the direct impacts of the development upon views of the landscape through intrusion or obstruction, the reactions of viewers who may be affected and the overall impact on visual amenity, which can range from degradation through to enhancement.

The interactions between the landscape and the viewer are laid in the views and view corridors. *The Image of the City* exposes the relationship between the five components of urban landscape and the positions of the views and view corridors. For example, the so-called landmarks are often located in some highly visually sensitive regions in the city, while paths often contribute to the view corridor.

Landscape and visual issues often play a prominent role in environment assessment. Unlike less obvious impacts such as changes in groundwater quality, changes in the landscape have a direct, immediate, visible effect upon people's surroundings, and therefore may arouse strong feelings. They may also be used by the public as a focus for a variety of other concerns about the impact of a development. Therefore, it is essential that assessment of the landscape and visual impacts of a proposed development are carried out in as measured and controlled a way as possible. This will involve not only careful prediction of the nature and scale of potential changes, but also systematic assessment of the significance of those changes for specific landscape and visual resources (IEATLI, 1995).

In some countries the scenery is well protected. For example in the Swiss constitution it is stated that the scenery has to be taken care of and in the case of a great interest of the general public, it has to be preserved undiminished (Lange, 1994). In the state of Wisconsin, in the USA, scenic beauty has assumed an importance in the law that currently serves as a major consideration in many of the state's regulatory functions. In 1952, the State Supreme Court ruled that the "right of the citizens of the state to enjoy our navigable streams includes the enjoyment of scenic beauty". The court held that "the occupancy (by the public) is visual" and that indeed the enjoyment of the beauty of the land constitutes a legitimate public use of land whether or not the public is allowed to set foot on it (Bishop and Hull, 1991).

In Scotland, as in the rest of Britain, political and economic policies are still the major influence on decisions about locations for new industrial developments. Already, much of its lowland landscape has been intruded upon by extractive industry and urbanisation, and its highland landscape by reservoirs for both water supply and hydroelectricity (Aylward and Turnbull, 1977).

Although local government has at its disposal sophisticated planning legislation, the community is still concerned that fundamental changes may occur in the physical and visual quality of their environment and often suspects that planning and approval may be given to a development without the full disclosure of effects on the community. Thus, local government in a rural area is often motivated by pressure groups and community to impose stringent planning conditions which ensure that both the developers and the community are aware of the effects of the development and the alternatives available. The presentation of the evidence must be in a form that can be clearly understood and assessed by parties (Aylward and Turnbull, 1977).

Landscape and visual impacts can arise from a variety of sources. They can be caused by changes in land use, for example mineral extraction, deforestation and land drainage; by the development of buildings and structures such as power stations, industrial estates, roads and housing developments; by changes in land management, such as intensification of agriculture use, which can be a vehicle for biological and landscape change; and less commonly, by changes in production processes and emissions, for instance from chemical, food and textile industry plants.

There may be different sources of impact at various stages in the life of a project, such as during construction, operation, decommissioning and restoration. For example, during construction, sources of impact may include site access, haulage, materials storage and large equipment; whereas during operation, permanent infrastructure, lighting and workforce traffic may be the main concerns.

2.2 The visual impact assessment process

There are relevant specifications on executing the visual impact assessment in both Europe and America. There are differences in some details. However, they are very similar in content. In the United States of America, such a program called "Aesthetic environmental quality evaluation process" can be outlined as in Table 2.1 (Smardon et al, 1985).

Table 2.1 Aesthetic environmental quality evaluation process

<table>
<tr><td rowspan="2">Phases:</td><td rowspan="2">Activities:</td><td colspan="3">Feasibility Study Level of Detail</td></tr>
<tr><td colspan="2">Preliminary detail of reconnaissance study</td><td>And revised during pre-construction planning</td></tr>
<tr><td rowspan="2">Defining Resources</td><td>Identify Resources</td><td colspan="2">Identify resources based on scopping study that area:
1) Likely to be affected
2) Significant</td><td>Identify the Viewshed of the project using the prototype design form</td></tr>
<tr><td>Develop Evaluation Framework</td><td colspan="2">Define an aesthetic quality evaluation process using the aesthetic evaluation framework matrix</td><td>Identify the key viewpoints within the viewshed. (Create visual simulation for use in aesthetic quality evaluation)</td></tr>
<tr><td rowspan="3">Inventory Resources</td><td rowspan="2">Survey Existing Conditions</td><td>Classify the Various Landscape Viewsheds (Management Units)</td><td>Classify the various visual Landscape types (Visual Resources)</td><td rowspan="2">Classify and evaluate the existing landscape within each visual simulation</td></tr>
<tr><td colspan="2">Rank the landscape types and viewsheds, and combines to create a composite map of selected visual characteristics</td></tr>
<tr><td>Forecast "Without Plans" Condition</td><td colspan="2">Forecast the without plan conditions for the study area to revise the composite map</td><td>Forecast without plan conditions for the viewshed and revise the existing landscape evaluation</td></tr>
</table>

	Forecast "With plan" Condition	If alternative project sites have not been determined, make assumptions about the potential alternatives project types.	If alternatives project sites have been determined, use the generic prototype of each project to forecast with plan condition to revise the composite map	Forecast with plan conditions for the viewshed using the anticipated project design
Assess Effects	Identify Effects	Identify relevant qualities of the generic prototype design form for each likely alternative	Identify any changes in landscape character or landscape views. (for each alternative)	Create a visual simulation of the anticipated project to identify the visual impacts
	Describe Effects	Describe the potential effects of each generic prototype within the various landscape types and viewsheds	Describe beneficial and adverse changes in the landscape character within each selected viewshed	Use the V.I.A. rating form to describe the visual impacts of the project
	Determine Significant Effects	Rank zones of the composite map with respect to the potential effects of each generic project alternatives	Determine which changes of the visual landscape are significant effects	Determine which visual impacts are significant effects and to what degree
Appraise Effects	Appraise Significant Effects	Recommend sites for each project type based on the ranked zones of the composite map	Explore mitigation measures for all significant adverse effects	Explore design alternatives for the project and other mitigation measures to eliminate or reduce the significant effects
	Judge net E.Q. effects	Select sites for further study (Return to forecast with plan condition activity in next column)	Select recommended project alternative(s) and location(s)	Select recommended design form and management activities

The dimensions of the visual impact assessment relate to IEATLI (1995):

• visual compatibility with surroundings	e.g. massing, height, shape, proportion and rhythms of building elements, colour and material used;
• visual obstruction	e.g. blocking of view corridors towards landmarks and

	notable landscape features;
• improvement of visual quality	e.g. clearance of visual obstruction and blight, appealing design features that enhance attractiveness of the landscape;
• glare from direct or reflected sunlight or man-made light source	e.g. uncomfortable views caused by glare from structures faced with mirror or polished materials or from direct light sources generated from the proposed development.

In assessing visual impacts, it is important to cover all possible viewpoints. If this is not practicable, key viewpoints should be selected on major routes e.g. roads, walkways, footpaths and hiking tracks; and at activity nodes e.g. residential areas, important public open spaces and landmarks etc. The location of these viewpoints should be typical. When considering views from a main route, it will be more effective to have a sequence of views recording the changing visual events along the route.

According to the specifications of the IEATLI, the negative impacts to the original landscape should be mitigated. Mitigation is not only concerned with damage reduction but should include consideration of potential landscape visual enhancement. Wherever possible design that would enhance the landscape and visual quality should be adopted. Alternative design that would avoid or reduce the identified impacts on landscape, or that would make the project visually compatible with the setting should be thoroughly examined before adopting other mitigation or compensatory measures to alleviate the impacts. Possible measures that may mitigate or compensate the impacts include (IEATLI, 1995):

• remedial	e.g. screen painting, facade treatment, colour

	scheme and texture of materials used;
• compensatory	e.g. landscape treatment, compensatory planting, creation of interesting landscape or visual features.

Although the process of the visual impact assessment is guided by some standard specifications, it still can not be overstated that the above process is not enough. In the research domain, many people are still trying to break through the existing circumstances and improve the quality of the evaluation. They mainly focus on such topics as landscape description, visual impact identification, and improving public accessibility to the urban landscape planning process.

2.3 The information inventory in the visual impact assessment

In the common visual impact assessment process, the urban landscape resources inventory classifies the landscape themes according to land use and landscape characteristics. It at least covers the following:

- Physical aspects such as geology, landform, drainage, soil, and climate, including micro-climate;
- Human aspects such as cultural features, local history, buildings and settlements, people affected and their perception of the landscape character; and
- Aesthetic aspects such as the views available, visual amenity and visual character.

Wherrett (1996b) summarized researchers utilize three view types to describe the interactions between the landscape and the viewers. They are single, panoramaic, and corridor views. The single view can be divided into distant and close views. Distant and close are terms describing a concept. They have been coined to enable scoring of the landscape with respect to observer value judgements and predict scenic value for units in which only the data on the landscape elements are known. They are views characterized by the distance of the horizon and the land immediately below the horizon, from the observer. A working definition of "close" may be one in which the observer can discriminate between features of interest. Corridors are characterized by the existence of lateral terrain features such as valley sides or woodland on either side of the observer, constraining their view to a narrow field. Photographic panoramas are usually made up of a number of laterally overlapping photographs taken in a sequence around 360 degrees with the disjoins evident.

2.3.1 Landscape simulation

There are at least four kinds of roles that landscape simulation might serve in the context of landscape aesthetic policy development, implantation, and evaluation: (1) to serve as a tool for enforcement of public rights to know the aesthetic consequences of environmental modifications; (2) to serve as negotiated legal documents in the context of existing policies; (3) to help establish perceptually based performance standards in land use regulation; (4) to assist in the assessment of monetary penalties for aesthetic damages (Bishop and Hull, 1991). In the visual impact assessment, the landscape simulation acts as the main media to present the visual impacts to public and facilitate public perception of the graphical expression.

A wide range of landscape simulation methods have been developed and implemented as tools for impact assessment. These include: plans, diagrams, elevations, perspective sketches, renderings, modified photographs (photo rendering and photomontage), slide projections, scale models, movies, videotapes and computer graphics (Oh, 1994). Photomontages are often used to get a subjective impression. However, it is a relatively expensive method and is restricted to fixed observer locations (Zewe and Koglin, 1995).

Computer based simulation methods include: two dimensional drafting and painting; three dimensional frame models; surface and solid modelling; image processing; and animation techniques (Wherrett, 1996). Computer generated perspectives are very helpful in assessing development options at an early stage in the assessment/design process. The eye level of the viewer can be adjusted if required for example, to test potential views from upper floors of buildings (LEATLI, 1995).

Computer aided design (CAD) software is effective for the complex scene simulation. It can map photographic images as textures to improve the realism of simulation. The scene can also be animated into movies or high resolution pictures by various rendering algorithms. By merging photographic documentation of the existing site environment with computer renderings of CAD models, the future appearance of that site can be simulated. Quick Time VR (QTVR) is an image based panorama. QTVR also provides functions to support predefined interactions such as navigation in the virtual environment.

Previous studies have tended to focus on the realism or accuracy of simulation. But simulation can not reproduce reality completely. Rather, it selects critical aspects of that reality for the particular purpose at hand (Appleyard, 1977). For environmental planners and designers, representation of these critical aspects could improve the visualization of their schematic concepts or detailed design ideas. In practice, more significantly, the simplification or abstraction of detail is directly related to the savings of effort, time and costs of simulation. This situation is very true for computer simulations, and the perceptual effectiveness of abstracted computer simulations needs to be tested.

Visual simulation is only descriptive; it does not release the planner from the difficult task of evaluation nor does it provide an evaluation in itself in a publicly based evaluation approach. However, visual simulation is, or at least should be, the prerequisite to predict and to evaluate the visual consequences of planned alterations (Lange, 1994).

2.3.2 Visual impacts identification

Both visualization and intervisibility analysis play important roles in the assessment of visual impact. Intervisibility analysis for visual impact assessment includes viewshed calculation and set operations. Its output can be projective maps or reflective maps. The objective of the former is to reveal the extent of visibility from the development to its surroundings. The latter's objective is to determine whether, and to what extent, the development is visible from its surroundings. There have been few comprehensive programs to incorporate visualization tools into an environmental resource modeling system, or to systematically evaluate the usefulness and applicability of such systems to agency and public decision making settings. In some areas there are comprehensive resource models, but lacking visualization capabilities. In others there are well-developed visualisation tools but poor links to quantitative modelling (Orland, 1992a). Homana et al. (1999) developed a specific Geographic Information Database for landscape evaluation. They utilized professional GIS software to accomplish the precise viewshed and visibility calculation, but lacked three dimensional simulation. Kan et al. (1999) integrated CAD, Quicktime VR and 3DS to assess the visual impact of the construction of an electricity substation, but did not provide an quantitative analysis. This situation shows the importance of the integration of both simulation and intervisibility analysis. It reveals both the physical visual impact, which is mapped as viewshed, and the visual impacts on landscape character.

Aimed at assisting design, CAD programs often lack spatial analysis. That makes the frequent computation of viewshed analysis in visual impacts a heavy task. Long serving as geo-analysis software, geographical information system (GIS) excels in spatial analysis. With the integration of both spatial analysis and three dimensional analysis modules in GIS, users are empowered to accomplish precise viewshed and intervisibility computation. The visual impacts of newly developed constructions or planning on specific features can be revealed by overlaying the feature maps with the viewshed map.

2.4 Public participation

As one factor of the landscape assessment, the public itself is also needs to be analyzed. Public preference and perception of the urban landscape is analyzed first. Then, the public's role and its accessibility to the urban landscape planning process are exposed. These above two aspects clarify the public participation in the planning process.

2.4.1 Public preference in the urban landscape

There are five general factors of design elements for assessing landscape preference: the characteristics of the observers; the medium selected for presentation; the response format; the relevant environmental attributes of the settings; the nature of the transaction with the specific setting (Hetherington et al, 1993). The first two of these are also mentioned by Tips and Savasdisara (1986) as being the two basic factors of influence: the interviewed subjects and their characteristics, such as age, gender, familiarity with landscape, nationality or occupation; the characteristics and the origin of the rated landscape scenes and the dimensions of the medium used for presentations.

A variety of cultural, social and demographic factors have been shown to be factors in the environmental and aesthetic preferences of the general public (Anderson, 1981; Lyons, 1983). It also appears possible that landscape appreciation is linked more to perceptions of the subtleties of landscape and the interaction between elements than to the presence or absence of single or readily observable landscape attributes (Penning-Rowsell, 1982).

Many different social and demographic factors have been shown to influence the perception of landscape. Age and familiarity with a particular site are noted as being of high influence. In addition to these, Land Use Consultants (1971) noted the following factors as influential to the perception of landscape: previous experience of landscape, gender, education, and environmental awareness.

Age

Lyons (1983), Bernaldez et al (1987), and Balling and Falk (1982) did research on the age-related differences in landscape preference. The preference scores for vegetation biomes fluctuated according to the age of research subjects in Lyons's research. It decreased for the young children, then stabilized or rose for adults, dropping again for elderly people. His research also showed that the coefficient of variation around the age group mean tended to increase with age. There are significant age related changes in the preference for landscape that differs in terms of floristic organization in Balling and Falk's (1982) research. They also showed that the preference could be modified by subsequent experience.

Familiarity

Land User Consultants (1971) noted the knowledge and familiarity of a landscape as factors affecting perceptions of landscapes. Wellman and Buhyoff (1980) did research to demonstrate that a particular regional landscape could not arouse greater visual preference in the subjects even if they were informed beforehand of the geographic difference. They also showed that the regional familiarity might not be a control problem for landscape researchers because subjects from different regions evaluated the landscapes, in terms of preference, in essentially the same manner. However, in the study of Lyons (1983), it is shown that a person's landscape preference is strongly influenced by his or her residential experience in different biomes. A similar result came from the research of Balling and Falk (1982). In their research, the highest preference among the adult groups for each of the biomes was demonstrated by the foresters, who were the most familiar of their study groups with a range of natural envrionments.

Previous experience of landscapes

Previous experience of landscapes has a "profound influence" on human perception and preference, according to Balling and Falk (1982), who state that landscape preference is undoubtably not simply a function of some innate preference. Purcell (1992) comments that humans experience each new or previously encountered landscape within the context of mental models of previous landscape experience.

Gender

Gender influences the amount and nature of societal learning, which may affect landscape preference. It is also an important social differentiator of people's attitudes toward the natural world (Lyons, 1983). Indeed, Hull and Stewart (1995) showed that men and women look at different objects while walking, with men more likely to be viewing the ground, topography and ephemeral objects.

Education

Another important social differentiator is education (Lyons, 1983) - in a study by Balling and Falk (1982) college students had more favourable attitudes towards wilderness than secondary school students. Education can also be linked to the perception of crowding in a recreational landscape. Glyptis (1991) found that higher educated people were less tolerant of crowding than those with less education. However, this was not found in a study based on a loch and forest landscape (Wherrett, 1994) where higher educated people were more likely to accept a higher level of crowding.

Environmental awareness

It has been suggested that there is an environmentally aware public and an environmentally unaware public, who possess quite different perceptions (Dearden, 1981). The former are often members of environmental organisations, a factor which has been shown to indicate a variation in attitude towards natural landscapes (Harvey, 1995).

Buhyoff et al (1978) did an experiment to ascertain whether landscape architects could determine the rank order of a series of landscapes as they were preferred by another group of subjects, based on knowledge of what this group had said they liked and did not like about the landscapes.

The results showed that the landscape architects, given general information as to what a sample of people like and don't like about a set of photographs, can come quite close to reproducing the client group's rank orderings of those photographs. Planners may be able to assess people's preferences by asking them what they do and do not like about landscapes, but they cannot and should not rely on their own preferences in planning for people. It is desirable for planners to make some assessment of people's expectations and preferences rather than relying on their own judgement (Buhyoff et al, 1978).

It is believed that there is an association between the viewer position and the expected viewer satisfaction, and that the aesthetic experience may be determined from a combination of the texture and pattern of the land cover information and the plan form of the viewshed. It is also believed that there are relationships between the number and shape of the horizons present within a landscape and the pleasure experienced by the viewer (Baldwin et al, 1996).

However, the descriptive inventory method comes only from professional perception of the urban landscape. As mentioned in T*he Image of the City*, the legibility of the city plays an important role in the public perception of the urban landscape. Confusion can bring negative impacts to public assessment of the amenity of the landscape.

2.4.2 Public accessibility to the urban landscape planning process

The process of urban planning can be divided into several stages. In the first stage of a project, planners interview, poll, survey, distribute questionnaires, or conduct their investigations to infer the customer's requirements and form the project's norm and specifications. In the second stage, limitations are analyzed to weigh the project feasibility. In the third stage, the project is prototyped and simulated to assess its impact on the existing environment. Urban landscape management is particularly concerned with visual impacts.

To infer public concern for the potential visual impacts on existing landscape, planners conduct surveys, distribute questionnaires, or collect people together to have community meeting. They define the visual environment, which will possibly be affected, simulate the project, and determine the visual impacts on intervisibility from main viewpoints and view corridors, and on the visual amenity of existing landscape.

The traditional survey and questionnaire are limited in conveying the prospects to the public. If planners cannot precisely capture public appreciation of existing landscape, people will not prefer answering those questions. In addition, surveys take a long time to accomplish. Taking a community meeting, planners can communicate with the public in detail about the scenic features. They have more freedom to choose the media to present the visual impacts. However, a confrontational atmosphere often exists in this kind of communication. Planners, who chair the meeting, are viewed as elite persons. Public participants care more about the proposal's impacts on their own visual rights. Traditional static simulation only detects visual impacts on a few main views. So, planners are often unable to answer participants' questions such as: what will be seen if I stand somewhere else? In addition, a weakness of the community meeting for public participation is its limits in time and place.

CHAPTER THREE

CAPTURING THE SYSTEM SPECIFICATION

This chapter specifies a web-based system to provide a collaboration mechanism for public participation in the visual impact assessment of urban landscape. It includes considerations of functional requirements, user interface design, project management, interactions between 2D analysis and 3D simulation, and the integration of quantitative analysis and 3D simulation.

3.1 General considerations

3.1.1. Functional requirements

The visual impact assessment of a proposed development addresses three types of issues: spatial, quantitative and qualitative. Spatial issues include where the development is visible from, or more specifically, what or whom it is visible to. Quantitative issues include how much of the development is visible, how much of the surrounding area is affected, and to what degree. Qualitative issues include the visual character of the development and its compatibility with its surroundings. The first two issues arise from the changes of the intervisibility for a given development. The qualitative facet of the visual impact assessment lies more on people's subjective judgement and is hard to quantify. However, it is also based on the outcome of the spatial and quantitative analyses. Homma et al (1999) utilized a specific mathematical model called Analytical

Hierarchy Process (AHP) to assist the evaluation of visual impact from a designed garbage processing plant based on the prior viewshed analysis.

The principle of intervisibility states that visibility is determined in two ways: either from the site, or to the site. It includes both being viewed from outside of the development's boundaries and viewing from the developing site to adjacent areas. In GIS's 3D analysis, they are both under the calculation of viewshed. Viewshed analysis determines all visible or invisible area in the city from given viewpoints or view corridors (ESRI, 1997). The view corridor is the corridor from the viewpoint to the scenery. In urban areas, view corridors often follow the routes of roads, rivers, or other paths. In landscape design, visibilities between scenery are often maintained for good visual effects. It is also necessary to maintain some visual relations between important landscapes in order to form the whole visual landscape effect. View corridors show the dynamic characters of urban landscape. They affect the layout and height of buildings, as well as the layout of plant. In contrast with static analysis of intervisibility and its low efficiency in the demonstration of view corridors, 3D simulation exhibits dynamically the variations of scenery when walking along a view corridor through animation.

Besides the viewshed and view corridor, there are also some other factors that should be considered in designing a specific GIS for visual impact assessment. Within a city, different areas show great differences in their visual values. Even when it comes to a single building, some façades contribute more than others to its visual character. Those make it necessary to rate constructions according to their visual values. The visual impact of new construction also involves intersection with existing construction.

3.1.2. Project management

From the viewpoint of engineering, the process of urban planning can often be divided into three parts: capturing the requirements, feasibility analysis, and design. Visual impact assessment often stands in the front part of them. It reveals the project's degradation or improvement of the original urban landscape. In the first stage of a project, planners interview, poll or do some other investigations to infer the customers' requirements, and form the project's norms and specifications. All limitations are analyzed in the next stage to weigh the project's feasibility. This includes the future expenses, national and regional polices, natural environment of the site and some other objective qualifications. The design is then modeled to simulate the future situation and also assess its visual impacts. If those concerned are satisfied with the design, planners can congratulate themselves on their success; otherwise, they have to repeat the whole process from the beginning. That includes revising the design, simulating the project, and consulting the public. This often makes the whole project a lengthy and repetitive process. It also shows that visual impact assessment should be managed in projects as an important part of the whole urban planning process.

GIS assists planners to quickly capture their customers' requirements for the visual environment, even if people have only some vague idea of what they want. Actually it is often hard for them to imagine the outcome of planners' design based on maps, and discussion or some other well-organized communications can often invigorate their inspiration for what visual environment they desire. GIS and the (World Wide Web) WWW are ever evolving technologies with the potential for public use allowing greater involvement in environmental decision making. Web based GIS models future scenes of the planning site in either two-dimensional or three-dimensional forms and publishes them on the Internet, giving people a vivid impression on the outcome of the project. Broadcasting visual impact assessment to public desires more on web based GIS.

For quick prototyping, it is desirable to integrate both the design and the evaluation modules into one system. But popular GIS systems show low efficiency for 3D design and inhibit those used to finishing their design with CAD software. Import of data from another kind of software greatly challenges the inter-operatibility of GIS. Although popular GIS software, such as Arc/Info, Arcview or MapCAD, have specific extensions for the import of CAD data, the semantics of data structures defined in GIS and CAD are different. This makes it important for developers to customize the imported data from other software to be in GIS style. The reverse situation seems the same. The outcomes of visual impact assessments are often stored in the database as electronic maps. These need to be reverse transformed into CAD or other software data formats according to their semantics.

3.1.3. User interface

Many commercial GIS programs allow software developers to customize the user interface according to specific requirements. Following the current software's style, the user interface of the specific GIS for visual impact assessment (VIA) should be graphical. However, the gap between the system and the public still exits, due to the unfamiliarity of the public with GIS and the virtual environment. That challenges the specific GIS for

VIA not only in the system functions but also the user interface and system work style. The latter often contributes more to the public's acceptance of the specific system. In this research, a special query language, which extends SQL, is designed to facilitate planners in the VIA process. The extended SQL is aimed to be in an oral style accompanied by some jargon in VIA, which makes it easier to understand. Queries are transformed from standard SELECT-FROM-WHERE format into SELECT-FROM-WHAT IF format. The input of query statements can be in text or graphic form in a customized Web page. The latter empowers the user to interact with spatial objects on the displayed map while composing the query statement. For example, to finish the query on visible area from a given viewpoint, the user can set up the viewpoint in the WHAT IF clause by selecting its identify code in the candidate listbox or directly pinpointing it on the map. The system maps the specific spatial analysis for VIA into meta-operations of the extended SQL. This includes the viewpoint selection, view shed analysis, and Boolean set operations. The user's interaction with themes or spatial objects on the map is also introduced into the SQL statement's formation. For instance, to answer "what if" questions, the system empowers the user to do some editing operations on line or polygon objects in the active theme. The result will be included by the WHAT IF clause.

3.1.4. Web access

There has been detailed discussion on utilizing the Internet to facilitate surveys or questionnaires. Recently, specialists in the field of GIS have had a hot discussion on empowering the public to participate in the planning process. The so-called Public

Participation GIS is aimed at bridging the gap between GIS and lay people. Public accessibility to such kinds of "elite technology" contributes the most to such involvement. As the number of households with Internet access increases and the demographic profile of Internet users diversifies, the potential for using the World Wide Web for public participation in planning increases exponentially (Al-Kodmany, 2000). R. Kingston (1998) outlined researches that examined the potential of the Web as a means of increasing public participation in environmental decision making. He considered traditional methods of public participation and argued that new Internet-based technologies have the potential to widen participation in the planning system. The advantages are clear for participants, including privacy, freedom from time pressures and constrains, and freedom from influence by an interviewer. All these contribute to alleviate confrontation between participants and planning agencies.

3.1.5 Qualification of public participation in urban planning

Although the public's involvement in the planning process contributes to democracy and promotes public satisfaction, it is still beyond most people' imagination to substitutes untrained public opinion for planners' professional judgement when it comes to urban landscape planning. Common practice in traditional methods of public participation quite often involves an atmosphere of confrontation. The public is empowered more freely to acquire information on site planning, express its opinions, and even object to proposals in virtual communities. Professionals in the domain of design and environmental planning are viewed to have a more sensitive appreciation of landscape quality and are also thought to be able to express their feelings more articulately (Dearden 1981), while citizen interest is thought by some to be lacking in landscape evaluations because of the inherently subjective and somewhat intangible nature of the problem (Wherrett, 1996a). There is also a concern about creating a critical mass of users to sustain meaningful Internet interactions. Some initial attempts at creating public discussion sites have withered because of the lack of message activity (Al-Kodmany, 2000).

As mentioned earlier, the user interface and system work style play an important role in working GIS and VIA accessible to the lay public. Most of people have no idea of spatial analysis, and virtual reality. The user guide for the system can release a lot of the unfamiliarity with the graphic interface. As mentioned before, the visual impact identification was defined as a query process. That makes it is possible to develop a standard query clause generation panel to aid public in identify the visual impacts on their concerned areas or themes.

Normally, in the domain of landscape evaluation, the descriptive inventory approach contains several assumptions. One is that the value of a landscape can be explained in terms of the values of its components. Another is that scenic beauty is embedded in the landscape components, that it is a physical attribute of the landscape. However, scenic beauty depends on the observer as well as that which is observed (Arthur et al., 1977). Public perception may be superficial and more intuitive than professional judgment. Lacking professional training and often low in their analytic abilities, laymen cannot explain the basic reasons for the degrading or upgrading of urban landscape from development. As to the urban landscape planning process, they have difficulty in giving conducive suggestions to planners. It's feasible to let someone make an assessment of the visual impact as to whether it's good or bad. When asked to explain why, their answers are often not reliable. So the dependability of the public's assessment should be checked.

3.2 Envisioning the proposed web based system

Although the rendering of urban models in web browsers often lacks vividness compared with specialized stand-alone applications, VRML modeling proves effective in rendering urban scenes over the Internet. The 3D simulation for visual impact assessment requires not only static scene rendering, but also some specific interactions. For example, it should allow users to "walk" in the virtual urban environment, select viewpoints, set up parameters such as height, range of view, and orientation, and automatically generate the scene. Panorama and view corridor are another two simulations to be provided for visual impact assessment. Although popular VRML viewers such as Cosmo player provide some wander simulations, users are often disoriented when they "walk" in it. The obfuscation often leads to perceptual distortions of the virtual urban landscape, which can interfere with people's assessment of the scenic beauty and make the subjective assessment inconvenient and unreliable. To eliminate such disorientation, the system integrates both a two-dimensional map and a three-dimensional model of the urban area in the user interface. The interaction between 2D map and 3D world includes the matching of an avatar' position, visualization of its view orientation and range, and the setting up of viewpoints and view corridor. To support the Web based assessment, the whole system is based on Client/Server architecture. The map is managed database management system (DBMS) on the server end.

The 2D map is actually a Web GIS based on Client/Server architecture. In this system, it not only aids the orientation of avatars for wandering in the virtual environment, but is also customized to accomplish some quantitative analysis based on intervisibility, such as viewshed area from given viewpoints, visual sensitivity analysis, and cumulative visual impacts.

The integration of Web GIS and a Web based three-dimensional simulation brings other advantages to public participation in visual impact assessment. The system provides a log mechanism for public participation. People's operations and evaluations are logged into a special database that includes their intervisibility analysis, communication, and navigation in the virtual environment. A professional can rebuild the scene according to someone's parameter set, which includes position, viewpoint parameters, tour route and other information. After re-experiencing a participant's navigation in the three-dimensional simulation environment, professionals or some other highly respected people can evaluate the dependability of participant's assessment.

3.2.1 Proposed virtual collaboration

Although the potential for Internet based collaboration is diverse, in this specific system, the virtual collaboration consists of improving participants' access to visual imact assessment, and capturing the public appreciation.

3.2.1.1 Improving participants' access to the web based visual impact assessment

The distribution of processing between the client and server ends makes the Internet based complex spatial analysis or query possible. Web based GIS empowers developers to publisher their maps on the Internet, lets people access them, pan, zoom in or zoom out. By customizing the Internet Map Server, the system can even accomplish some complex analysis or query. Most people have little understanding of spatial analysis, or spatial query in GIS. The customization of the user interface utilizing Java programming provides flexibility to accommodate different kinds of people.

Even though the Web GIS has great potential in empowering people to accomplish spatial analysis on the Internet, many stories of public participation in urban planning based on Web GIS still indicate low public involvement. Normally, GIS describes the physical world layer by layer according to the classification system and spatial attributes. This is different from people's perception of the physical world. The overlay technique facilitates professional spatial analysis, however, it also confuses laypersons. The gap between symbolic electronic maps and the natural scene contributes the most to people's aloofness to the Web GIS.

In this Web based system, the electronic map is the main media to represent the natural scene and the visual impacts. To compensate for the gap between the two-dimensional map and the natural three-dimensional scene, the system development emphasizes the design of the user interface and provides spaces for collaboration among the public. For example, if one wants to know the visual impact on a specific area from a proposed project according to a given viewpoint, he need only to pinpoint the viewpoint, set up the parameters, and then draw the concerned area on the map or select the related theme on the client. After receiving all that information, the server will automatically generate the visible area and invisible area according to the position and parameters of the viewpoint, intersect them with the concerned area or theme to generate the impact areas and symbolize them, then notify the client end to retrieve and display the results. The server performs the analysis according to instructions written in an embedded macro language, such as the Avenue language in Arcview GIS. If the user is interested in the names of impacted objects, or wants to know more about the attributes of the impacted objects, the server first computes the visible area, then utilizes it to complete the spatial query on the concerned themes. The result will be described in an html file and transferred to the client.

The user interface design of this system conceals all the details of spatial analysis. It is customized into a more natural style query than the standard SQL. As explained earlier, it implements some special SQL-style spatial queries to facilitate people's comprehension of the visual impact assessment based on two-dimensional thematic maps.

To facilitate communication among the public when they want to collaborate on the visual impact analysis, the extended query language also allows users' notation for the intermediate or final results. That transforms the format of the query language from SELECT-FROM-WHAT IF into SELECT-<name it>-FROM-WHAT IF-<described as>. The "name it" is a label for user to give a name to the result of query. The "described as" is a label for user to describe the details of the "WHAT IF". The oral styled spatial query for visual impact analysis can be generated in text format by the software.

The extended query language can describe the complex process of visual impact analysis in a clause. As mentioned earlier, the spatial query of visual impact is often consists of several steps. It includes viewpoint or view corridor setting up, the concerned themes selection, and Boolean set operations. This serial process can be integrated into a single query clause. Compared with accomplishing the above process serially, the user can often have a clearer understanding of what the thematic map of the impact area symbolizes. It mitigates the gap between the public and the professionally viewed Web GIS.

The communication methods such as chat on line also contributes to facilitate people's perception of the electronic map. Imagine involving a GIS specialist into the virtual community. He can act as an agent on the Internet to introduce the meaning of the symbolized map to lay people. In addition, the virtual collaboration compensates for people's memory limits. One may be familiar with a specific area in the whole urban landscape, while the others can inform him about the situations of other areas, thus making his sense of the whole area more clear and complete. This contributes a lot to the determination of the degradation or enhancement of the visual impact.

3.2.1.2 Capturing the public appreciation

Normally, in the domain of landscape evaluation, the descriptive inventory approach contains assumes that scenic beauty is embedded in the landscape components, which are physical attributes of the landscape. So the beauty of components and the main views of them should be managed. The evaluation detects the visual impact on the components of urban landscape.

This system design considers not only the preferences of the landscape elements but also the combination of them. In addition, the amenity of landscape is determined not only by what can be seen, but also by the view itself, e.g. the height of view and view angle. How to manage the amenity information in the GIS database challenges the database design.

Attributes of each feature are managed by a popular relational database management system. Each spatial object is related to its attributes by an identity code. The spatial objects are classified according to their landscape characteristic. Most landscape elements are stored in the polygon theme. To represent public appreciation of specific landscape elements in the database, data views are created to store the index to the highly preferred landscape elements. These views are defined as a data mapping from the landscape database according to specific preferences. The key viewpoints are also stored in the database. The information not only includes their positions, but also the height above terrain, the horizontal and vertical view angles and the amenity rating. Additional descriptions of the amenity can also be added into their attributive data set. View corridors are also stored as polylines in the database as a specific theme.

The views storing the public preferred landscape elements should be initialized as null at the start of the assessment. In the running process, participants can add their preferred landscape elements into views. The participants also add their concerned viewpoints and view corridors into the database. The system generates views according to each participant's preferences. Thus the system stores each participant's appreciation of landscape elements. When multiple participants collaborate in registering appreciated view, the database reflects their common preference. Statistical analysis of the indexes from views of the landscape elements exposes the public appreciation. In addition, the key viewpoints and view corridors can be selected by statistical analysis based on information of participants preferred viewpoints and view corridors stored in the database.

3.2.2 Collaboration between planners and public

The system connects the planner and the public in the whole process of the visual impact assessment of the urban landscape. It aids the planner in capturing the public appreciation of urban landscape, and determines the main viewpoints and view corridors. It also provides a channel for the planner to negotiate with the public on the degree of the negative impacts to the existing landscape. Because the system provides spatial query of the visual impact analysis on the client end, the user can precisely assess the impact to his or her concerned area or landscape elements. That makes the consultation more reliable and substantial.

The public participation is also logged and managed by the database system. It includes the information on participants' preferences for the landscape elements, definitions of key viewpoints and view corridors. Participants' assessments of the visual impact from the proposed project is also stored in the database.

The planner first qualifies those assessments utilizing the log information. This includes the objective and reliability of their assessment. Although public involvement in the planning process contributes to democracy and promotes the public's living standard, it is still considered unreasonable to substitute the public's myriad opinions in place of planners' professional judgments when it comes to urban landscape planning. Because the participants' viewpoints and view corridor information are stored in the database, planners can utilize that data to evaluate the reliability of public assessment of the visual impacts and the degree of the negative impacts.

The visible area from the publicly preferred viewpoints should be defined as the valued theme representing public appreciation of the existing landscape. The intersection area of such places is often the most sensitive in visual impact. In this area, the facilities generating negative impact should be prohibited. Conversely, the intersection parts of the invisible areas from the publicly preferred viewpoints can be utilized to locate these facilities.

The view corridor analysis is more complicated and not as straightforward as the key viewpoints analysis. Because the view corridor is often presented as a polyline on the map, it is hard to define its visible or invisible area. However, the intervisibility from other viewpoints to the view corridor can be determined. The intersection of the visible area from the proposal site with the view corridor can be defined as the visual impact on the view corridor. The proposal site is often represented as a polygon or polyline on the map. One approach is to sample several view points to represent the whole. Another approach is to obtain the site's linear outline, represent it as a polyline, compute the viewshed from the polyline, and get its impact on the view corridor. The difference between these two approaches is that the former can generate more detailed information on visual impact. For example, it can tell the planner which façade contributes to the visual impact. The latter approach only tells the planner that there exists some visual impact to the view corridor.

CHAPTER FOUR

SYSTEM DESIGN

From the specifications and the vision of the system in Chapter three, it can be seen that software or toolkits required to develop such a system should be able to support real time display and interactions of 3D scenes. As a GIS system, a large amount of spatial data and attributive data also should be stored and managed in the database. In addition, to run on the Internet, the system should have a distributed architecture. Fortunately, forerunners have developed some mature software and toolkits to fulfill these specific requirements.

There are two ways to develop such a practical distributed system. One is to utilize some mature commercial GIS support system such as Arcview 3.1 or Arc/Info with 3D extensions. The system developer just needs to customize the functions provided to his own requirements. The other way is to develop independently by use of some free toolkits such as VRML2.0, Java, or Java 3D. This means more challenges to developers. Not only must the specific analysis support functions be programmed, but also some basic functions such as the data management.

4.1 Main software or tools for developing the proposed web based system

The candidate software tools are considered according to four criteria:

- data management, including both spatial data and attributive data;
- system architecture;

- spatial analysis provided by system as basic analysis tools and evaluation of whether it fits the requirements;
- allowance of human machine interface specific customization.

4.1.1 Arc/Info or Arcview with 3D analyst and Internet mapping server extensions

The Arcview 3.1 with its Analyst extension turns conventional 2D flat maps into dynamic, interactive 2.5D views. Users can create and display surface data in three dimensions for analysis and visualization. It supports three primary data types for modeling 3D features: grids, triangulated irregular networks (TINs), and shapfiles (2D and 3D). Grids and TINs are used to model continuous data or surfaces. Three dimensional vector features, where X, Y and Z values are stored for every vertex, let users capture and precisely represent geographic features. Both 2D and surface 2.5D data can be viewed in perspective using the Arcview 3D Analyst Scene Viewer. With the viewer, a user can rotate, zoom in and out, and pan the data from any angle in a scene. As a desktop GIS system, Arcview excels in the flexibility for user customization

Similarly, Arc/Info 8 provides connections to the Internet. As an enterprise GIS system, Arc/Info provides more flexible and robust functions in data input or output: for example, cartography, digitizing or data transfer between different data formats.

Arc/Info and Arcview share a lot of spatial analysis. Because of the inherent similarities in function, I just use Arcview as representative of these systems.

From the viewpoint of data management, there are not too many differences between 2D and 3D GIS by Arcview. A special data base system manages spatial data in Arcview. All spatial objects including the buildings, terrain, and so on should be classified before import into the database. The data gained from digitizing the spatial objects is grouped into layers according to classification or usage. One layer may include many individual spatial objects. Every spatial object has an ID number that acts as the connection key between the spatial data and attributive data. The attributive data is managed by a relational database management system.

The Arcview GIS system originally runs as a stand-alone application on a workstation or PC. To make it run over the Internet, especially according to the client/server mode, some extensions are added. The architecture of the whole system can be diagrammed as in Figure 4.1.

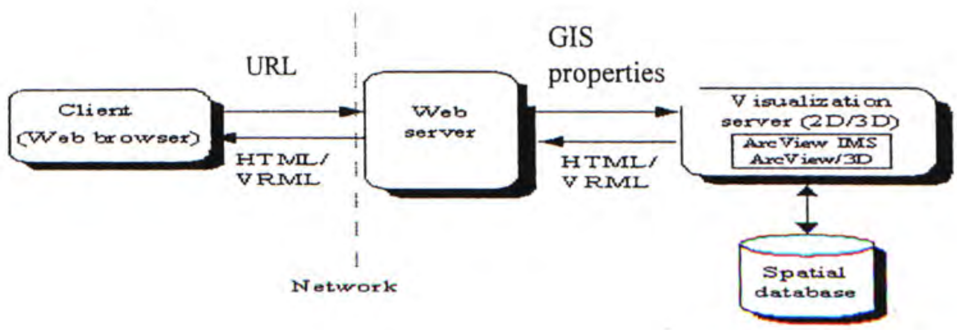


Figure 4.1: Arcview system architecture with web extensions
(Huang, 1999)

The visualization server retrieves data from the database and exports it into HTML and VRML formats. The web server is in charge of communication with the client over the Internet. At the client end is a web browser with support for VRML and Java. It acts as the interface for user interaction.

With Arcview spatial and 3D Analyst extension, users can perform such basic analyses as:

- determine the height at any location on a surface;
- cut and fill. The volume of material lost or gained in an area after a change.
- View Shed. Areas on a surface that are visible from one or more observation points are known as view sheds. For any visible positions, users can discover how many observers can see that position. In addition to controlling the height of an observer, the view-shed function can provide constraints on how far, how high, and which direction an observer can look.
- Line of Sight. Line of sight determines whether a given target is visible from a point of observation. If the target is obscured, the coordinates of the first obstruction are given. Users can also find out what is visible along the line of sight.
- Neighborhood Analysis. It establishes relationships between nearby features so that questions pertaining to proximity and area of influence can be answered.
- Interactive 3D. The data can be viewed from any angle by rotating and tilting the object in the viewer. The user also has control over zooming in and out, panning, and flying forward or backward.
- Control of Light Source. Shading illuminates a theme to add a sense of depth and realism. Changing the position of light source is easy, and shading can be turned on or off.
- Spatial intersection or union operation between any two given themes.

System developers should group all these basic functions to fit professional analyst's requirements. The toolbars and control panel can be customized. Utilizing the macro language of the GIS software, a developer can integrate the analyses into complex transactions. The customizing of the user interface on the client end requires a lot of Java programming work to extend the default Java Applet named MapCafe.

4.1.2 VRML 2.0 and Java

Modeling is to establish a description of the world. It is the first step in visualizing the geographical data. A comprehensive description should at a minimum include the geometry, topology and appearance of the world, illumination condition and viewer attitude (Shan, 1998).

VRML (Virtual Reality Modeling Language) has become an industry standard for describing virtual worlds over the Internet. With a VRML browser, one can interact with the view so that any part of the world can be examined at any orientation and scale.

VRML uses a directed acyclic scene graph to describe the 3D world. Entities in the scene graph are called nodes. Nodes store their data in fields. Nodes can contain other nodes and may be contained by more than one node. By organizing the nodes and specifying their values, one can model the geometry and topology of the geographical information. Corresponding nodes can define illumination and appearance of the world as well. In addition, image textures such as terrain and urban area, which can be obtained from DPS (digital photogrammetry system), can be mapped on top of the geographical surfaces. Another distinct characteristic of VRML is Levels of Detail (LOD). If objects are defined in different versions of detail from coarse to fine, the VRML browser can then automatically choose and display the appropriate version based on the distance from the viewer.

Using the External Authoring Interface (EAI) linking Java applications to the 3D VRML scene, it is possible to program Java applications with an interactive user interface using VRML (Kim et al, 1996). EAI is a kind of application programming interface (API) to allow the Java applet or application to interact with the VRML scene. This interactivity enables a Java applet to dynamically build and update the data in VRML. This nature of EAI makes it applicable to various fields using dynamic visualization (Brow, 1999).

Using EAI to implement a web based 3D GIS application has three benefits. First with EAI, we can utilize the functionality of the VRML browser featured mainly in the navigation functions. Second, a VRML scene can be dynamically built and updated via the EAI, based on data received by Java applets, and in turn, the applet's data can also be dynamically updated through the VRML interface. Third, a web based 3D GIS applet that utilizes EAI and a VRML can easily be accessed by any platform having only java enable web browser with VRML browser plug-in. Supporting low cost and platform independent clients is one of the main reasons to utilize VRML and Java for developing toolkits (Kim et al, 1996).

As a modeling language, VRML 2.0 can only statically describe the three dimensional world. The object's spatial information is embedded in the components of the 3D world. Developers can utilize the annotation node to add attributive data to each component. The vividness of the simulation is only determined by the complexity of the modeling.

There has been no mature DBMS system to manage the models of VRML. By use of Java's JDBC extension, the system can connect the client end to a database server, so the attributive data management can be realized. The combination of VRML 2.0 and Java interface provides flexible means to customize the human machine interface. Programming can fulfill some flexible virtual reality interaction.

Figure 4.3 illustrates a typical architecture for developing such a distributed 3D GIS utilizing VRML and Java (Brow, 1999).

The Attributive data includes not only text descriptions, but also multimedia data such as movies, photos and so on.

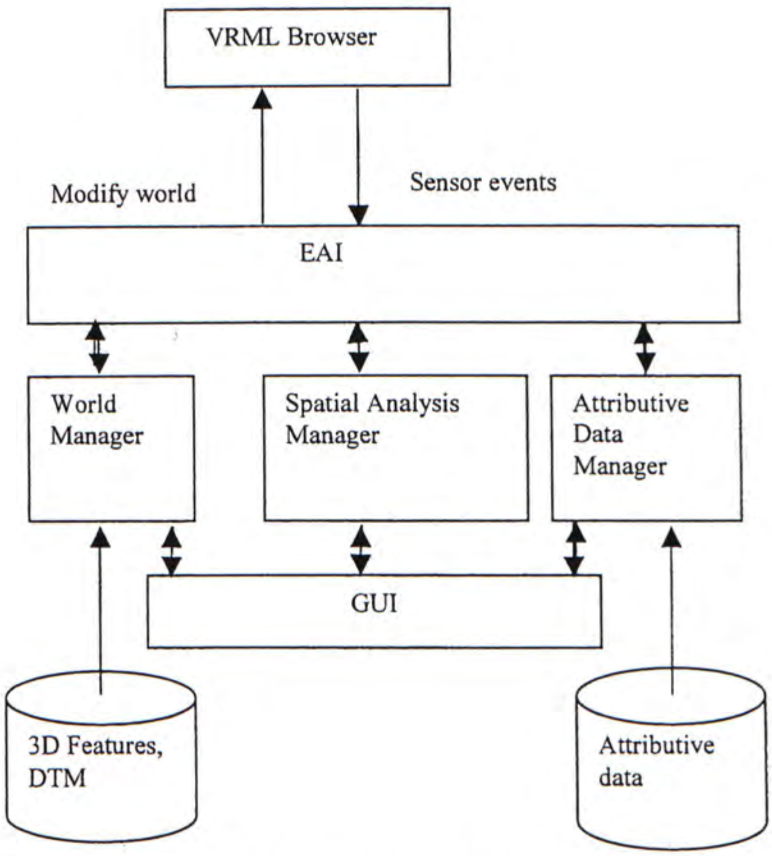


Figure 4.2: VRML and Java ystem architecture, (Brow, 1999)

Until now, there is no documented research on accomplishing spatial analysis based on VRML modeling. Most people utilize the GIS to do the analysis and export the results into the VRML format to visualize them in 3D.

As to the user interface customization, because there have been many free VRML 2.0 browsers available on line, developers are freed from programming the VRML browser. The EAI provides flexibility in the interactions between the three dimensional simulation and other Java applet in the same browser. Developers can customize the user interfaces with Java graphic user interface programming.

There have been many articles on using a VRML-Java Interface for developing a web based 3D GIS application system. Arcview 3.1 3D extension also provides a set of tools for 3D analysis; many special applications based on Arcview 3.1 3D have been developed.

4.1.3 Java3D API

The Java 3D API is an interface for Java programs to display and interact with three-dimensional graphics. Developers have already used Java 3D to build applications in a variety of domains including mechanical CAD, animation previews, GIS, 3D logos and educational offerings. Usually a Java 3D virtual universe can be described as in Figure 4.3.

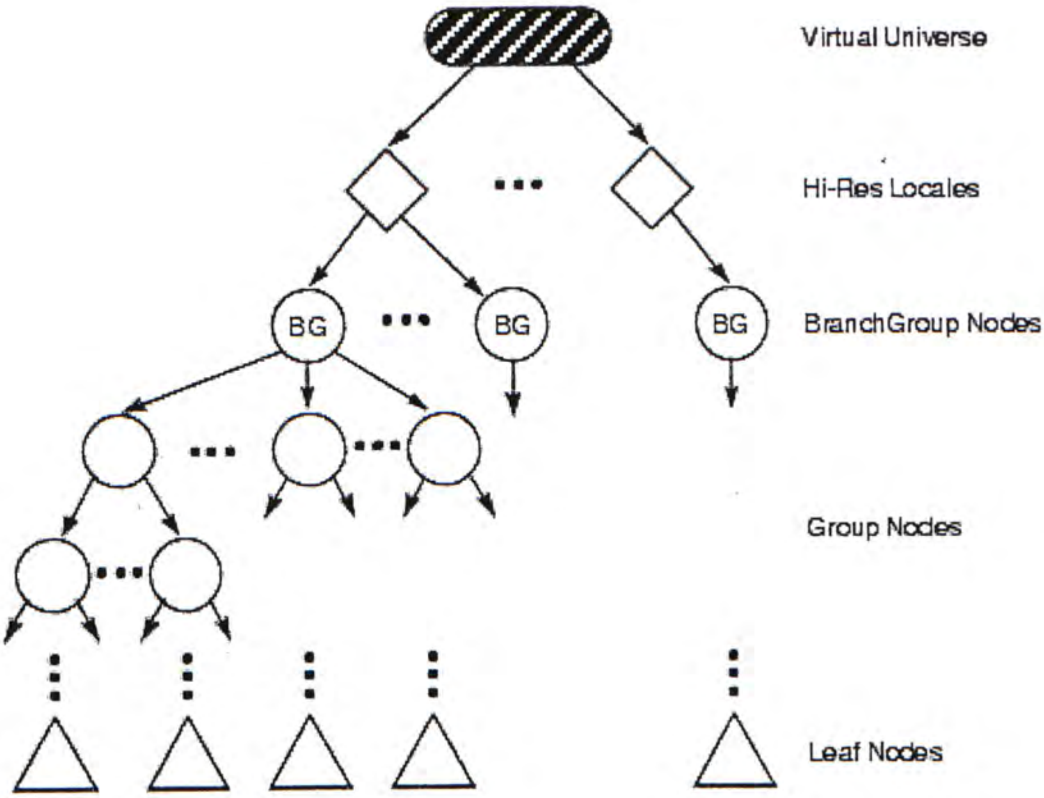


Figure 4.3: Java 3D virtual universes
(www.javasoft.com)

Similar to VRML, Java 3D uses a directed-acyclic graph of connected nodes that describes the elements of a scene, how the elements are rendered at runtime, and how the user can interact with those rendered elements.

The Behavior Leaf node is a powerful, extensible class that allows programmatic interaction with the scene graph at run time. Behavior nodes have customizable sets of wakeup conditions which, when satisfied, trigger the behavior. When the behavior is triggered, the processStimulus method of the Behavior object is executed. The programmer is free to override the processStimulus method with custom code. Wakeup conditions for a particular behavior can be logically combined with Boolean constructs.

There are various wakeup conditions available in the Java 3D API. For example, WakeupOnElapsedFrames is triggered every time the specified number of frames has been rendered. WakeupOnAWTEvent is triggered every time a user-specified AWT event has transpired.

Java 3D includes the Interpolator class, which extends the Behavior class. Interpolators let one easily add animation to Java 3D programs. With Interpolator subclasses, one can add rotations, scales, color and transparency changes, and movements along a spline path with only a few lines of code.

As a recently developed API, Java 3D provides a more flexible means to build up a real time web based 3D graphics system compared with VRML. Similar to VRML, it has limits in spatial data management. For communication over the Internet, Java3D does not even have its own file format.

To build up a practical web based GIS system with the Java3D API means a great challenge to developers. Due to the lack of a standard interactive viewer or model file format, there has no successful commercial prototype.

In the research domain, some people developed a lot of modules in Java3D to visualize three-dimensional models. They even programmed a lot to accomplish some sophisticated spatial analysis, such as viewshed, buffer, flight simulation. However, it will take plenty of programming work.

In contrast, a toolkit approach such as Java3D requires a programmer to understand the structure of any object imported and to have sophisticated 3D modeling ability. It can also make it tedious to create and control 3D contents.

In principles of modeling, the Java3D is very similar to VRML 2.0. So, the method for data management, system architecture, or human machine interface design is the same as using VRML 2.0 and the Java EAI interfaces.

The Java 3D API is currenty widely used in the domain of Virtual Reality. Because of the complexity in building up a virtual world utilizing Java 3D API, it would be a great challenge to build up the whole web based 3D GIS system using only Java. For the consideration of applying a quick prototype developing model, it is seems more sensible to utilize VRML-Java Interface.

4.2 System configuration

4.2.1 System architecture

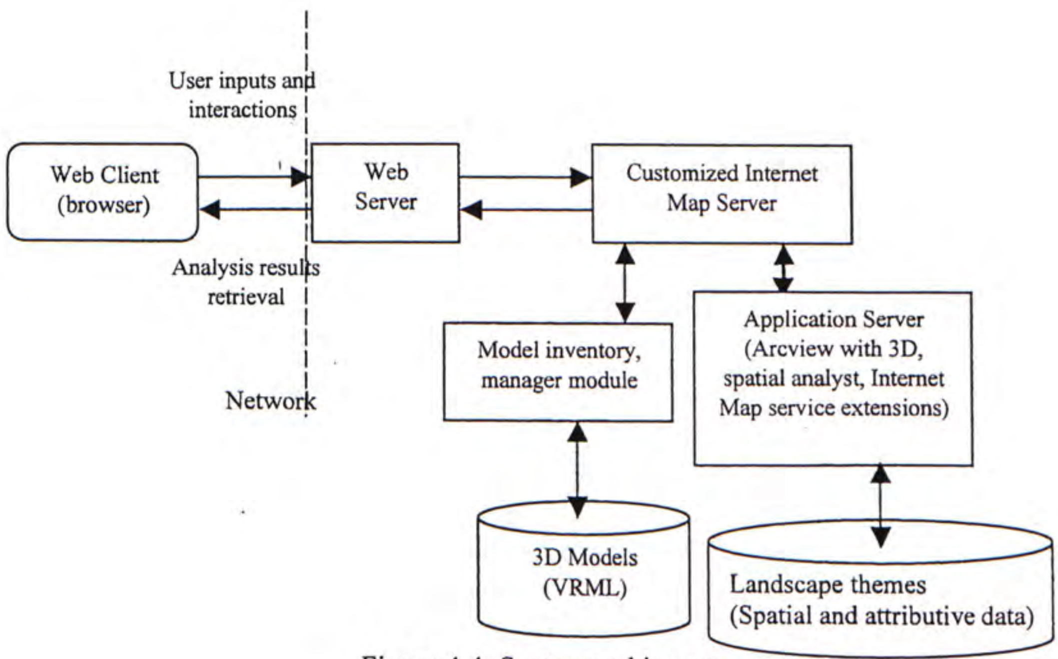


Figure 4.4: System architecture

Figure 4.4 shows the system architecture. The model inventory manager administers geo-spatial objects in VRML format and interacts with them via the EAI. The VRML file store includes the digital evaluation model (DEM), surface features and 3D features. The Arcview Application Server performs 3D spatial analysis and visualizes the results through its data transformation into VRML format. The result may also be presented in numerical or graphical form using the Java graphic user interface (GUI). The Application Server also handles the attributive data associated with special features. If the features selected by the user has related image or sound data, they can be displayed or played by using the Java GUI.

Arcview GIS integrates two kinds of database. The spatial database stores the geometric information for the objects, such as points, paths, and boundaries. An additional relational database stores attributive data. Each object has a unique identification number that links its spatial and attributive data.

Even though the proposed system utilized the commercial GIS system as the development platform, the thesis research did a lot of explorations. Different with most general Web based GIS or the Internet Virtual Reality system, the thesis research explored a lot on the improvements of the data management for urban landscape, the interaction between the GIS and VRML, and the database design and management of the public participation information. The urban landscape information management includes both the classification and the management of urban landscape themes, and the 3D urban landscape simulation. A specific server was developed to maintain the communication between the Web GIS and the VRML simulation. On the GIS server, the corresponding transactions of the spatial intervisibility query or other interactions were developed by the

Avenue programming. A lot of Java programming work was done to customize the graphical user interface of the MapCafe. The communication with the VRML simulation was realized by the EAI programming. User's interactions with the VRML browser trigger the corresponding embedded tracking objects to output the position or the orientation changing information of the viewer. After capturing the output from the VRML scene browser, the EAI sends that information to the communication server. The server will notify and update the corresponding information on the clients.

4.2.2. Data management.

4.2.2.1 Urban landscape information management

Urban landscape themes

Table 4.1 gives a typical classification schema for urban landscape themes. It relates directly to the organization of the server database, which can be a typical urban GIS system. The only requirement is that the information inventory should keep accordance with the urban landscape themes. Some information such as the cultural features, landscape history, people's perception and preference cannot be managed in visual, graphical formats. However, that information can be stored as attributive data and related to the corresponding landscape elements by sharing the same identification number.

Themes	Contents
Natural landscape Resources	Natural parks Community gardens Recreation facilities
Humanities landscape resources	Scenic spot Shrine and temple
Public utilities	Public Office Schools Hospitals Public Hall Harbours
Resident Areas	Residential quarters Apartment houses
Public Transportation	Main local road National roads Railway tracks
Planning project	Draft of the constructions design Reshaped Terrain

Table 4.1 Urban landscape themes

The data for the GIS system may come from different sources. Some data such as the terrain information may come from a photogrammetry system. The planning data may come from the MicroStation system. The drawings of the buildings are often in AutoCAD's *.dxf files. The merging and integration of data from multiple sources require transforming not only the data format, but also some semantics of those data. For example, in AutoCAD, users often draw the contour lines on the map directly to symbolize the terrain. The height values are often drawn onto the map directly as a separate layer. However, in GIS, the height value of each contour line is often stored in a database as attributive data. The identification number referes it to the corresponding graphic data of that contour line. In addition, the layer semantics are also different in AutoCAD and GIS system.

Urban landscape simulation

At the starting point, this development was confronted with the following situations:

- The system developer had to create his own 3D data as there was no suitable data available.
- Current commercial GIS software, such as Arc/Info, Arcview, or MicroStation support 2 or 2.5D data structures only. They cannot handle a 3D city model.
- 3D CAD package are able to edit such data. However, they are in not VRML2.0 format. Translation software is necessary to export the data to VRML2.0 format.
- The network has limited bandwidth for information transfer.

Due to the structure of the visual impact assessment process, the usage of different levels of detail is of great importance in data management. Based on several map scales, each level contains different details, which have a pronounced influence on the visual representation of urban landscape. Therefore, the main subject of visual impact assessment is not a perfect virtual replication of the city structures, rather it should convey a strong idea of the real project. These abstractions can be converted into visible representations that are called level of detail (LOD).

Urban planning experts often divide the urban landscape into three levels. They are the following.

1. Global: mountains around or in the city, sea, large lakes and rivers through the city, woods, prairie, etc. Some of the contents confirm the city structure and the others play a role as the background in visualization and psychology of the city.

2. Regional: urban parks, big grassland and central gardens, green corridor systems, hills in the city, lakes and small rivers or regional water systems. They are the landscape core element of the city foundation and should be combined to form a whole system. This level is the part changing the most from ancient times. It faces new challenges in how to coordinate the modern urban space and image formed by the much larger urban size, modern traffic system, and buildings in large scale, simple mass and geometric shapes.
3. Local: street gardens, street trees, landscape resources of local urban plazas, individual trees (significant due to size, age or local history) as land marks or meeting centers, ponds, private gardens, and other features close to the people's life and human scale. These are also the foundation parts of the systems in the regional level.

In contrast, computer graphics experts handle LOD on a purely visual basis, without regard to the object semantics. Köninger et.al. (1998) described several mechanics.

Distance of object. This method is important for different sized objects at the same distance from an observer. Here, the LOD for all objects at the same distance will change simultaneously.

1. Pixel area. Closer to the object, the number of visible pixels increases. After reaching a threshold value, the LOD switches to a higher resolution of details.
2. Dependence on visual angle. The LOD decreases with an increasing lateral distance from the center of vision. This method is similar to the usage of

architectural hand sketches. Discarding unimportant information, characteristic project aspects in the image center are stressed.

3. Explicit choice. For individual objects, structures or classes, the LOD information can be defined selectively.

As a first approach, the system uses three different levels of detail as shown in Figure. 4.5. For the first LOD, the bounding boxes of urban objects are considered, based on ground plans, as sufficient. The roads are drawn without any inventory, green areas are represented through flat shaded areas. The second LOD includes a precise positioning of the objects based on their ground plan with generalized fronts and roofs. Roads are presented with sidewalks and traffic line marking; green areas contain simple trees. In addition, phototextures can be used if provided. In the most detailed LOD, urban objects are represented with all geometrical data stored. Depending on availability and context of the project, the building fronts will be shown as simple geometry or as phototextures.

LOD1	Objects on basis of the grounding plan. Scale1:10000 to 1:1000
LOD2	Objects as simplified geometric bodies, including form of roof, facades realized as phototextures. Scale 1:1000 to 1:500
LOD3	Objects as complex geometric bodies, maybe with street inventory as phototextues. Scale 1:500, 1:200 to 1:1

Figure 4.5: Level of Detail

The different requested levels of detail can only be produced by fusion of several input sources. While the digital city map delivers the basic geometrical information (position of topographical objects, ground plan of buildings, height points of the elevation model), thematical data may be delivered by additional building measures and by the municipal registry.

Since real 3D data are still rarely available, system developers have to produce and manipulate their own data sets. Different data sets will be collected and fused to an integral 3D dataset with respect to the resolution of each source:

- Digital city maps represent the ground plans of buildings and streets, as well as tress, manhole covers, and other urban objects. Other datasets use this 2D digital map as reference data. Simple height information is used for a first approach to a surface model.
- Thematic data are available for single objects or object classes. Examples are: building age and condition, type of usage (operationally per floor), number of floors, building volume, floor space index, etc.
- 3D models may be constructed for individual buildings or other objects.
- Close up images or geodetic methods can be used at close distances. After preparation and correction the resulting image can be used as additional textual information for mapping in LOD2 and 3.

Building up the virtual world using level of detail.

Figure 4.6 illustrates the three levels of detail to model a complex object such as a single building. Object classes are defined for some basic objects of the urban space. With this mechanism, different objects can be grouped hierarchically. The resulting object classes take effect as self-contained units, which involve geometry for various levels of detail as well as related thematic data. As a result internal handling of this complex object is easy.

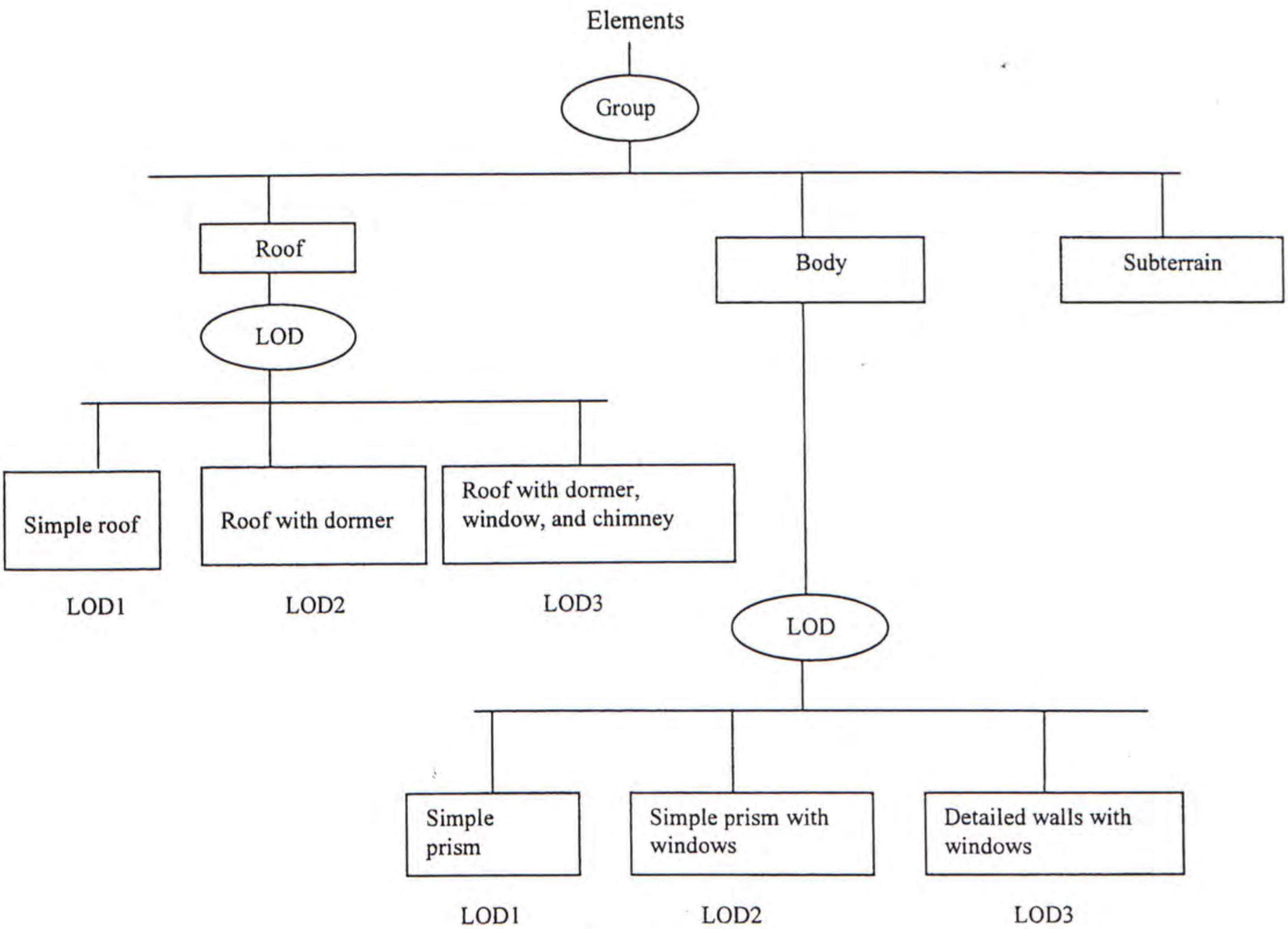


Figure 4.6: building in three levels of detail

The new object classes include:

- Sculpture, with identify number, type and 3 abstraction levels: bounding box, simple polyhedra or detailed polyhedra with textured faces.
- Street, with type name and 2 abstraction levels: median lines or side marker, pavement, lantern and signal nadirs.
- Green, with base area.

• Tree, with type, age and damage classification, and at first with only spherical tree crowns. The detailed crowns with polygon leaves.

• Terrain model.

In VRML, these classes are implemented as node kits. New datasets of these structures can be added to the database. In LOD1 the objects are described by geometric bounding boxes consisting of simple geometry and transformation information. LOD2 includes faces, ground plan and additional color information. LOD3 contains more detailed faces and image data as texture.

The changes of LOD are realized through so called, "switch" nodes. This special node is able to "choose" and switch between alternative child nodes. For access management of thematic attributes a custom node type is defined that includes the attributes of the datafields. This node is not involved in the visualization process of the scenery. Each node kit type includes finally a node called "label" which stores the database object-id (Db_ID) of the corresponding object.

4.2.2.2 Public participation

As mentioned before, there are three kinds of views. They are the single view, corridor, and panorama. Participants query the intervisiblity or make assessment of the views. The Figure 4.7 illustrates the concept model of the relationships between the participants and views in the proposed system. The single view and panorama refer the position of the viewpoint. The corridor refers the viewpoint as the starting point.

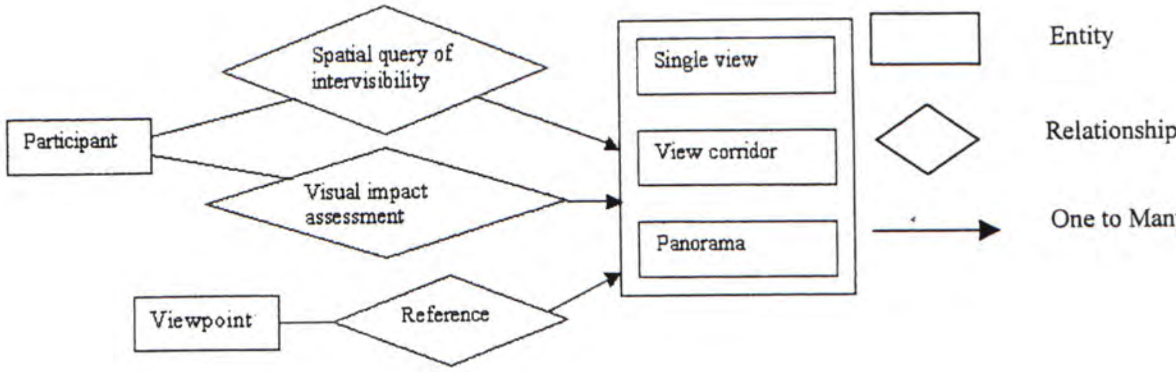


Figure 4.7: The concept model of the public participation

The schemas, that represent the management of the public participation, can be diagrammed as following:

The corresponding table name is parenthesized after the name of the object.

Viewpoint (Viewpoint):

VP_ID	Shape	Height	AFHLV	ASHLV	ALVLV	AHVLV	Name

VP_ID: unique identification number of the viewpoint (numeric);

Shape: the type of the spatial object. For viewpoint, the value is "point" (string);

Height: Height of viewpoint (numeric meters);

AFHLV: angle of first horizontal limit to view field (numeric degree);

ASHLV: angle of second horizontal limit to view field (numeric degree);

ALVLV: angle of lower limit to the view field (numeric degree);

AHVLV: angle of higher limit to the view field (numeric degree);

Name: the name of the viewpoint (string);

View Corridor (View Corridor):

VC_ID	VP_ID	VC_Name

VC_ID: the identification number (numeric);

VP_ID: the identification number of the viewpoint which this refers to (numeric);

VC_Name: the name of the view corridor (string);

Participants Profile (Participants):

User_ID	User_Name	Gender	Education	Age

User_ID: the identification number for each participant (numeric);

User_Name: the alias name of participant (string);

Gender: "male" or "femle" (string);

Education: Primary school (0), Secondary School (1), College (2), Master (3), Doctor (4), others (5) (numeric);

Age: age in years (numeric);

Spatial query on intervisibility (vpVIA & vcVIA):

VP_ID	User_ID	ITheme	Description	Name

VC_ID	User_ID	ITheme	Description	Name

VP_ID: the identification number of viewpoint this refers to (numeric);

VC_ID: the identification number of view corridor it refers to (numeric);

User_ID: the participant identification number (numeric);

Itheme: the name of the chosen impacted theme (string);

Description: supplement annotation added by user (string);

Name: the name of the result theme (string);

Visual Impact Assessment (VIA):

VIA_ID	User_ID	Assessment	Cause

Viewpoint referred by the VIA (vcVIA)

VIA_ID	VP_ID

View corridor referred by the VIA(VpVIA)

VIA_ID	VC_ID

VIA_ID: the identification number of the assessment (numeric);

VP_ID: the identification number of the viewpoint it refers to (numeric):

VC_ID: the identification number of the view corridor it refers to (numeric);

User_ID: the user identification number (numeric);

Assessment: visual impact assessment from participants (string);

Cause: user's explanation for their evaluation (string);

The logical model of the above schemas can be diagrammed as in Figure 4.8.

The system introduces a new mechanism to involve public participation in visual impact assessment over the Internet. The process is diagrammed in Figure 4.9. Participants are empowered to examine a project via web enabled GIS and VRML, to assess whether the visual impacts are good or bad, and to state the reasons for their assessments. In the next stage, these assessments are reviewed by experts or other highly respected participants. These may be trained professionals in urban landscape design, or others elected as "senior representatives" by a democratic vote. They evaluate the negative impacts as logged in the system's database and ascertain the root causes. The planners are notified, and they revise their design accordingly to mitigate the negative impacts.

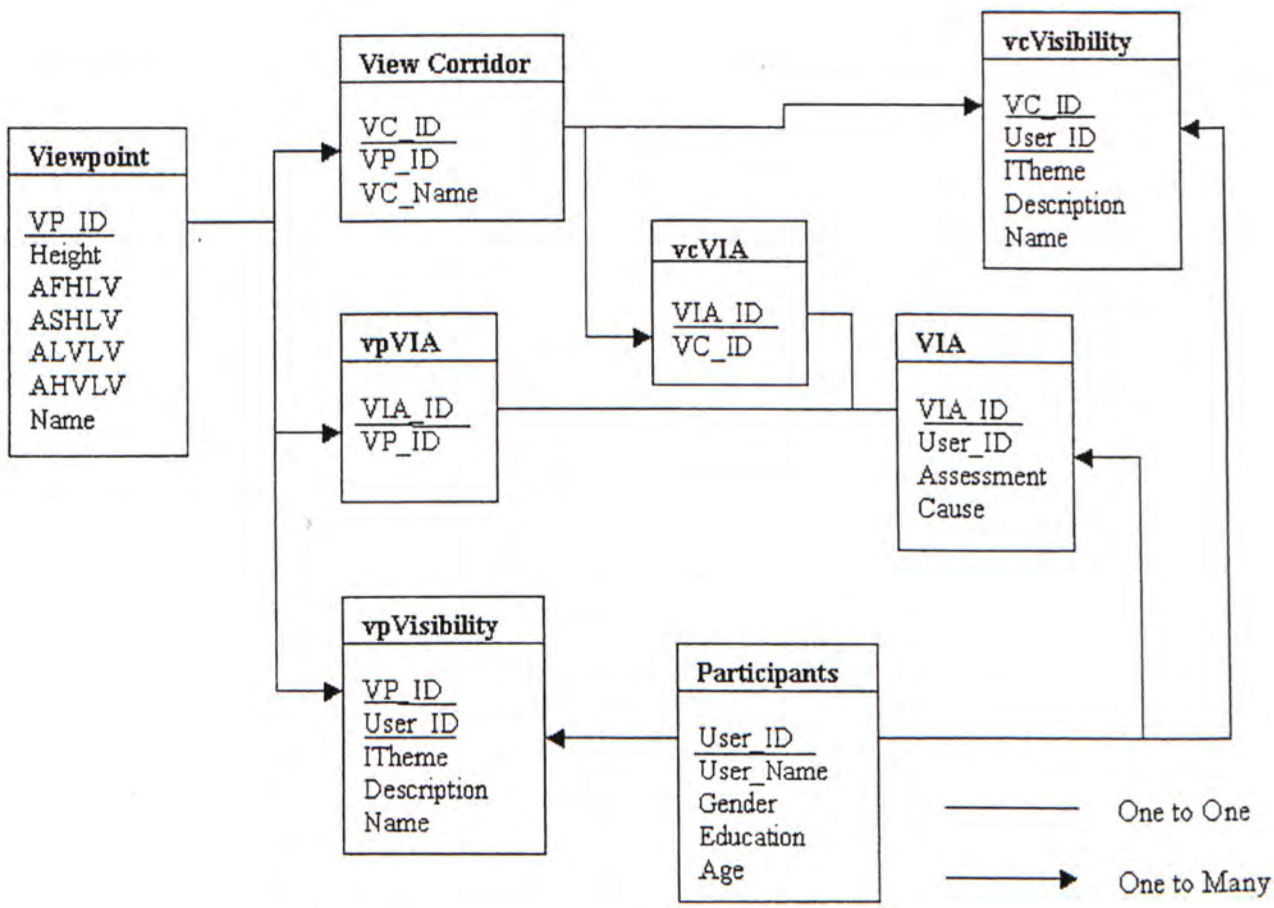


Figure 4.8: The logical model of the public participation

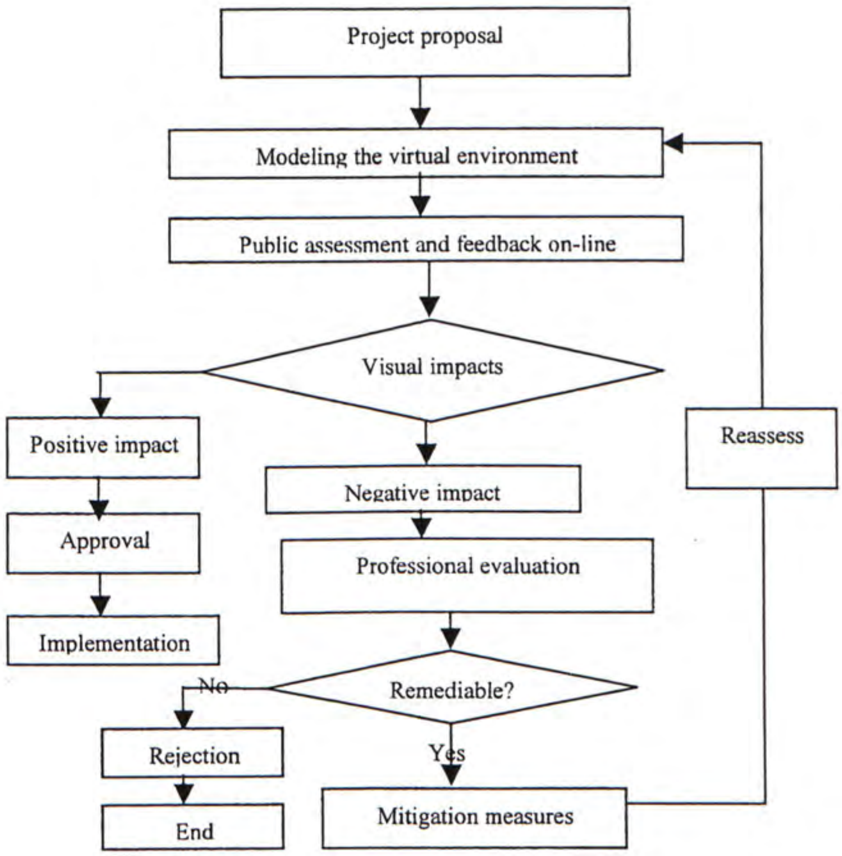


Figure 4.9: Public participation flow diagram.

4.2.3. User interface design

The user interface design provides the flexibility for users to interact with the system. On the client, the web based GIS is actually a Java applet named MapCafe, which is embedded in the html file. The whole window of the browser is divided into three frames. In the middle, the main part of the graphic user interface is the web GIS. Above it, the system-name frame shows the name of the whole system. Developers can add some additional brief description such as the names of the developers. To the left of the applet frame is the info frame. This area can serve multiple purposes. At the initiation of the system, it can be a user guide frame. Developers can add the introduction and user guide onto this frame. The detailed information often includes the meanings of each theme on the map. That can help the public's understanding of the map-based information inventory of urban landscape. It also tells users how to interact with the web-based system. For example, the function definition of each tool button is described in detail here. The info frame can also be utilized to show the results of the user interaction with the system. For example, if a query transaction is processed, the result can be described in html files and displayed in the info frame. In addition, if developers want to integrate both the web GIS and web 3D simulation into one browser, the VRML files can be put into this frame.

In the web GIS system, there are two kinds of bars parallel to the top of the map, separated by a space. One is the button bar. All buttons can be added onto this bar. The other is the toolbar. User customized tools such as zoom, pan can be added onto this bar. The differences between the button and tool are not only represented by their names, but also their functions and usage. Each button here is a transaction trigger for the system. If the user clicks the button, the system may ask him or her to input some parameters. Then the client will automatically include the user's settings in an URL and send it to the server to ask for service. In contrast, each tool is designed to aid the user interaction with the client system. For example, in a normal html based graphic user interface, a user cannot draw a line or polygon on it. However, as to the web GIS system, the interactions with the geographic themes on the map require the system to provide the flexibility of drawing on the map. For example, user may want to draw the view corridor directly on the map. The tool is only a method for the user to input some graphic information into the system. The transaction can be triggered only by the button. As mentioned before, the Web GIS is actually a Java applet named MapCafe. MapCafe includes not only the map, tools, and buttons, but also some other toolkits such as the message bar to give a simultaneous brief description of the button or tool, that is currently under the mouse arrow, the scale bar, or the coordinates of the current mouse position on the map.

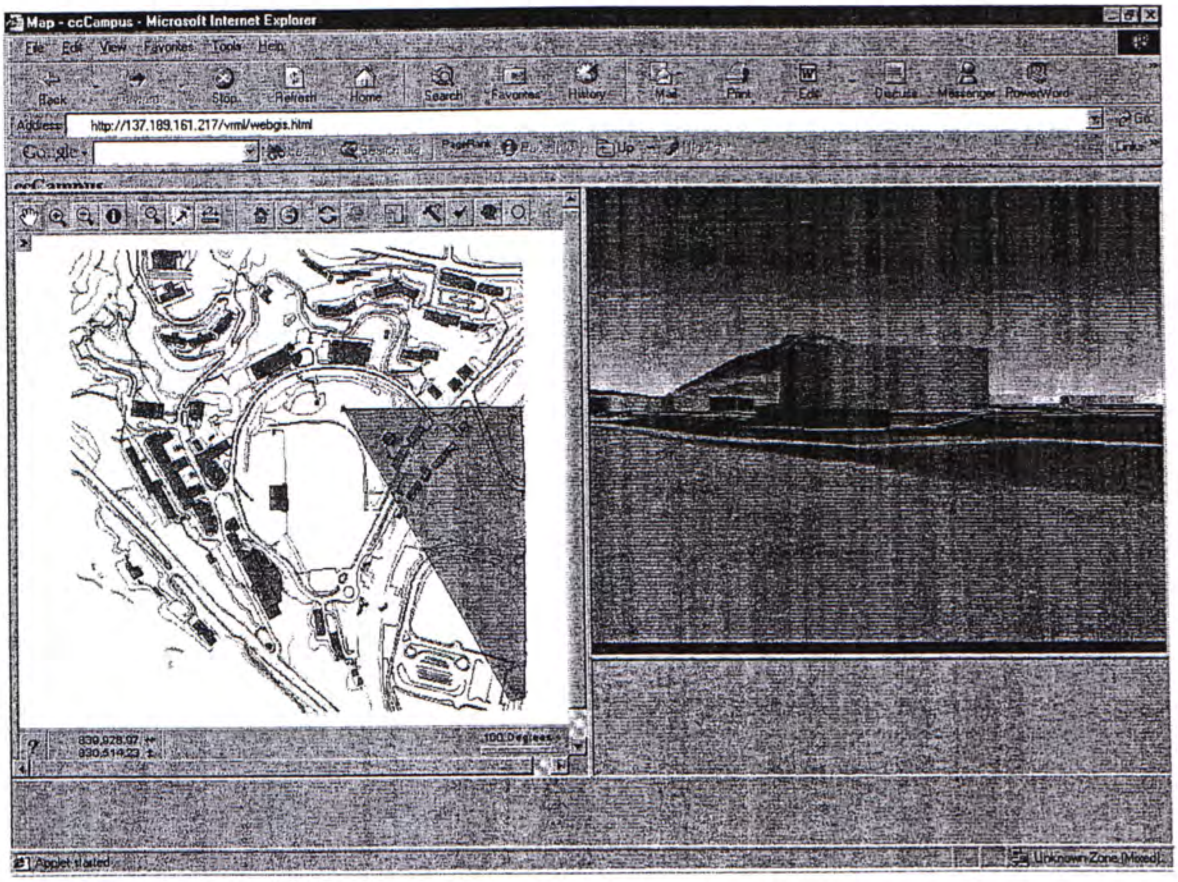
The Internet map server extension of Arcview 3.1 provides some superficial flexibility of the graphic user interface and MapCafe customization. For instance, the above frame structure can be customized. The MapCafe, the system-name frame, and the info frame can be integrated together or displayed separately in different windows. Arcview 3.1 provides a set-up panel to customize MapCafe. The tools, buttons, message bar, and scale bar can be selected by ticking the check boxes.

However, there are limitations in the set up panel provided by the system. First, it provides only some standard tools or buttons for user interaction with the system. For example, it allows the user to pan, zoom in or out, and query a theme by clicking on it. These can serve only as information broadcasting on the Internet. To empower the user to accomplish complex spatial analysis, and allow the public to participate in web based visual impact assessment, a lot of programming work was done to customize the MapCafe.

On the programming level, the Internet map server extension provides flexibility to change the definitions of the buttons or tools. Their functions can be redefined. Each newly defined function should be accompanied by the corresponding Java class in the MapCafe. The icons of the buttons or tools can also be customized. Developers can even add some brief description to each of them. To facilitate the user's graphic input into the web GIS, some specific drawing tools were developed. The user can draw a line or polygon onto the map. To enable the public to accomplish the complex analysis of intervisibility, two dialogs were developed. One is for setting up viewpoint parameters. The other is the Boolean set operation panel. When the viewpoint pinpoint tool is pressed, the user can position the viewpoint on the map by clicking the mouse. Following the click, a dialog pops up to let the user specify other parameters of the viewpoint. If the "OK" button on the panel is clicked, the position and the parameters of the viewpoint will be sent to the GIS server. The viewpoint will be updated on both the server and the client. If multiple users share the same viewpoint, all instances of MapCafe on the browsers will update their viewpoint theme. In the Boolean set operation panel, the user can accomplish the intersection or union operation between any two themes. The candidates are all listed in the panel's choice-box. For the consideration of the public's unfamiliarity with the web GIS, a spatial query panel on visual impact was developed. The user can utilize it to generate a query clause for visual impact on a specific theme from the predefined viewpoint or view corridor, describe it in a sentence, and display it in the textbox of the query panel to ease public understanding of the query. The Visual Impact Assessment panel provides a standard format for public to evaluate the visual impact. In this panel, participants should not only give their assessment, but also provide their reasons for it. Two situations were taken into consideration. One is for a participant standing on a predefined viewpoint. The other is for a participant walking on a predefined view corridor. Both the query panel and the visual impact assessment panel are triggered by buttons.

In the 3D-simulation part, the VRML viewer named Cosmo Player is installed previously. It provides interactions such as the zoom, pan, fly or walk through. As described before, the communication between the GIS and the 3D simulation is laid in a Java class embedded in the VRML models. The position and orientation of the viewpoint in the 3D simulation can be captured and sent to the GIS. However, it will be tedious to update the viewpoint in the GIS simultaneously. One candidate method is to put another button onto the web GIS bar. If the button is clicked, the viewpoint will be updated.

Typically, the graphical user interface can be illustrated by the Figure 4.10.



4.10: The typical user interface

In the above picture, the Web GIS and the 3D simulation are integrated into one browser. Because the communication between them is based on the EAI interface and Java network programming, they can be in two separate browsers.

CHAPTER FIVE

PROTOTYPE SYTEM AND PILOT STUDY

5.1 General description

In the prototype system, the user is empowered to accomplish the complex spatial analysis of visual impact over the Internet and involve himself in urban landscape management. People can select landscape elements on the map by drawing a polygon. The selected features are fed back to the server and stored as the public preferred landscape elements in the database. This is designed to aid the planners in capturing public appreciation of the landscape. The oral styled spatial query clauses for the visual impact from the user's viewpoint or view corridor are generated by a special input panel. This aims to facilitate people's comprehension of the visual impact assessment and improve their access to the system. The visual impact assessment is also customized into a standard format. The participants' explanations for their assessments can aid planners to determine the root of the degradation or improvement of the urban landscape. In addition, they also provide hints about mitigation measures for some negative impacts.

The prototype system for the virtual collaboration in visual impact assessment is a customized Web GIS system. Its system architecture is diagramed in Figure 4.4. In the following part, the client graphical user interface will be illustrated. Figures 5.12 to 5.14 show the process of a user's analysis of the visual impact. In Figure 5.12, the user sets up the viewpoint. The parameters include the height, and the horizontal and vertical angles of view. In Figure 5.13, the user sets up the view corridor by drawing a line on the map.

Figure 5.15 illustrates the user's query of the visual impact from his predefined viewpoint. The result is shown in figure 5.16. In figure 5.18, the user assesses the visual impact. Figure 5.17 illustrates the chat room for on line communication.

5.2 Implementation

Besides providing the visual analysis functions mentioned in the previous section, the system design also focuses on the interactions between the virtual environment and the GIS. It utilizes the GIS as a guide map for the user when navigating through the virtual environment. This aims to reduce the impediment to the visual assessment due to disorientation.

5.2.1 Connecting the two-dimensional world with the three-dimensional virtual urban environment

Because until now there is no commercial database management system to manage VRML models, I developed a special management system to inventory all sub models of the virtual environment. All entities in the virtual environment are identified by unique codes. The identification codes of objects are treated as primary keys in the server. The two dimensional map of the concerned urban area is managed by a GIS system. Spatial objects in the domain are classified and identified uniquely. The accordance of identification codes between spatial objects in both the GIS system and the virtual environment is also sustained. The Arcview Internet Map Server is customized to construct the Web based GIS system. The specific Web based spatial analysis for the intervisibility analysis is also developed.

The interaction between the two-dimension map and the three-dimensional virtual environment on the client is supported by a specific module programmed in the Java language. It includes the transformation of coordinates and communications between the two "worlds " via the EAI.

The virtual environment is modeled by popular 3D modeling software, such as AutoCAD, 3D Studio Viz and Arcview or Arc/Info 3D extension. They all have the extension to export 3D models into VRML format. The terrain is exported by Arcview GIS 3D extension, while other spatial objects such as buildings are modeled by any of various CAD systems and exported into VRML. They are pinpointed onto the terrain by utilizing a specific custom-developed module. The export process often hides the transformation of the coordinates. To unveil the correlation between the two coordinate systems (GIS and VRML), the system performs some statistical analysis on some sample points from each system. The assumption is that all transformations are the combinations of rotation, scaling, and translation. So, the relationship must linear. It can be expressed as a matrix multiplication of a coordinate vector:

$$\begin{pmatrix} X_{\mathrm{GIS}} \\ Y_{\mathrm{GIS}} \\ Z_{\mathrm{GIS}} \end{pmatrix} = \begin{pmatrix} A_1 & B_1 & C_1 & D_1 \\ A_2 & B_2 & C_2 & D_2 \\ A_3 & B_3 & C_3 & D_3 \end{pmatrix} \times \begin{pmatrix} X_{\mathrm{VRML}} \\ Y_{\mathrm{VRML}} \\ Z_{\mathrm{VRML}} \\ 1 \end{pmatrix}$$

Figure.5.1: Coordinate transformation

The statistical analysis software named SPSS was utilized to regress the correlation between the two coordinate systems. The R square and adjusted R square values are all near to 1.0. The regression confirms that all transformations are linear. This helped us to easily deduce the transformation between the GIS and VRML coordinate systems.

5.2.2 Data flow of the system for interactions between the GIS and VRML browser

Referring to the system architecture diagrammed in Figure 4.4, data flow control of the system can be outlined as follows:

1. Web based spatial analysis of intervisibility

Typically, the participant locates the viewpoint on the GIS map and sets up the other view parameters, such as the height of the viewpoint, and the angular bounds of the view field. The client program transfers them into the GIS coordinate system. The client generates a CGI request to notify the web server to trigger the GIS server to accomplish the predefined spatial analysis or query. In this prototype system, the program is the Arcview Internet Map Server. After generating the result, the Internet Map Server notifies the web server, which passes the result to the client for display.

The above describes the mechanism of the web GIS in general. Other kinds of web based spatial analyses follow the same pattern. For example, for set operations, the user chooses the operator such as intersection or union on the client through the customized set operation panel. Then the operation and the operands are sent to the server. The GIS server runs the set operation script according to the user input, generates the result, and returns the result to the client.

2. The interaction between the Web GIS and the 3D virtual scene

- Identify the spatial objects in the virtual scene

Assume, for example, that the user wants to identify a building with the ID number h01. He selects the object in the virtual scene by clicking on it. The building will be highlighted. It also triggers an event in the Java Virtual Machine of the browser. The ID number of the object will be captured by the EAI interface. The Web based GIS, actually a Java applet on the client end, will be notified of the ID number. The following process will be the same as the mechanism described before. The Java applet, named MapCafe, will generate the CGI request and send it to the web server for processing. The web server triggers the Internet Map Server to run the corresponding script program on the GIS server. The result will be generated and then the client end, which is actually the MapCafe, will be notified to fetch the result and display it in the GIS map.

- Track the positions of the participants

Because the Java language allows multi thread programming, a program that inherits the Thread class is assigned to keep track of the position of the viewpoint of the virtual scene. The change of the position or orientation of the viewer in the virtual scene will trigger the program to send out the current view parameters to the MapCafe by the EAI interface.

The following VRML script implements the event passing to the Java applet.

```
DEF PS ProximitySensor {
    size 5000 5000 5000
    center 0 0 0
  }

DEF ExampleClient Script{
       url ".\Viewpoint\Viewpoint.VRComm.class"
       eventIn  SFVec3f position
       eventIn  SFRotation orientation
       eventOut SFVec3f position_changed
       eventOut SFRotation orientation_changed

                              .

                              .

   }

ROUTE PS.position_changed TO ExampleClient.position
ROUTE PS.orientation_changed TO ExampleClient.orientation
```

The ProximitySensor is a VRML class to keep track of the position and orientation of the viewer in the virtual scene. The ExampleClient class inherits the Thread class. The

VRML ROUTE clauses connect the event output of the ProximitySensor named "PS" to the event input of the Script named "ExampleClient". The script invokes the Java class .\viewpoint\viewpoint.VRComm.class, which interacts with other Java threads via interprocess communication.

- Set up the viewpoint or view corridor on the GIS map to control the view in the 3D virtual scene

The user may click on the GIS map to pinpoint his position in the urban area, and use an input form to set the other view parameters. Then the position and the orientation of the viewer in the GIS will be transferred into the corresponding parameters in the virtual scene. Those parameters will be utilized to update the viewpoint in the virtual scene by EAI interface communication. The following VRML script implements that method.

```
DEF VIEWPOINT1  Viewpoint {
      position 77.333   -60.27  -89.015
      orientation 0.0 0.0 0.0 0.0
      description "view1"
  }
DEF ExampleClient Script{
    url ".\Viewpoint\Viewpoint.VRComm.class"
    eventOut SFBool bindView1
    eventIn  SFVec3f position
    eventIn  SFRotation orientation
    eventOut SFVec3f position_changed
```

```
    eventOut SFRotation orientation_changed
    field SFNode vpoint1 USE VIEWPOINT1
            .
            .
}
ROUTE ExampleClient.position_changed TO
VIEWPOINT1.set_position
ROUTE ExampleClient.orientation-changed TO
VIEWPOINT1.set_orientation
ROUTE ExampleClient.bindView1 TO VIEWPOINT1.set_bind
```

The continuous change of the viewpoint will show the animation effect. Multiple viewpoint objects may be defined in the virtual scene. The change from one viewpoint to another can be realized by utilizing the set_bind command in the ROUTE clauses.

5.3 Data preparation

5.3.1 Constructing the terrain model

I used the Chung Chi College campus as the experiment area for the system. The small inventory of land use types simplified classification of the data themes. Because the Chung Chi College campus is well planted, the green area was not picked out as a specific theme in the GIS database. The solution is to simply set the background of the map to be green. The roads, boundaries of the different land uses, and buildings are singled out to represent the outline of the Chung Chi campus.

As illustrated in Figure 5.2, the original data for the test case was the campus drawing of the Chinese University of Hong Kong. It is originally in .dxf format. It includes the ground contours and building outlines. All that information is merged into one map. To locate my experiment domain, a polygon theme was created and overlaid on the map as Figure 5.3. An aerial photo of the target area is shown in Figure 5.4. The intersection operation was utilized to isolate the Chung Chi campus from the rest of the whole university map. The process is illustrated in Figure 5.5. In contrast with GIS, the DXF file has no additional attributive data to connote the elevation of every contour line. It just marks the height by adding an additional layer. However, in GIS, to construct a digital terrain model for the surface, the elevation information is stored in the attributive data of the terrain and related to its corresponding contour line. Figure 5.6 illustrates the customized user interface to enable the model developer to add the elevation information into the attributive database of contour lines. When the user clicks on an unmarked line, two panels will pop up. One is for the elevation input; the other is for the attributive data list of the selected contour line. The modified contour line will be highlighted to illustrate the progress of the editing work. Figure 5.7 shows the rough digital model of the Chung Chi campus, including the terrain. The buildings are also extruded onto the terrain and the boundaries of different land uses, such as roads, sports areas, and pools, are overlaid onto the terrain model. To make the three-dimensional simulation more vivid, the high-resolution aerial photo of the Chung Chi campus is overlaid on the digital model, as shown in Figure 5.9. For the pilot study, it was deemed unnecessary to model every buildings of the campus in detail. As a sample, the Chung Chi church was modeled as shown in Figure 5.8 by utilizing the 3D Studio Viz software, then pinpointed and inserted into the terrain of the campus.

Detailed 3D simulation for the experiment would take a lot of work in the modeling. However, because three-dimensional geometric modeling isn't the emphasis of my research, I only built some rough 3D models to simulate the scene. The terrain data is transferred from an AutoCAD *.dxf file into a GIS shapefile, changed into a digital terrain model, and then exported into VRML format. In principle, all spatial objects can be modeled by various CAD packages and pinpointed onto the terrain. The terrain is overlaid with a high-resolution color aero-photograph to represent the texture of the ground. Texture mapping the façades of buildings can often make the urban landscape more vivid. It can be easily and efficiently accomplished by utilizing specific virtual environmental modeling software, such as the Virtual GIS from the ERDAS company, or VirtualZo from the Supresoft company.

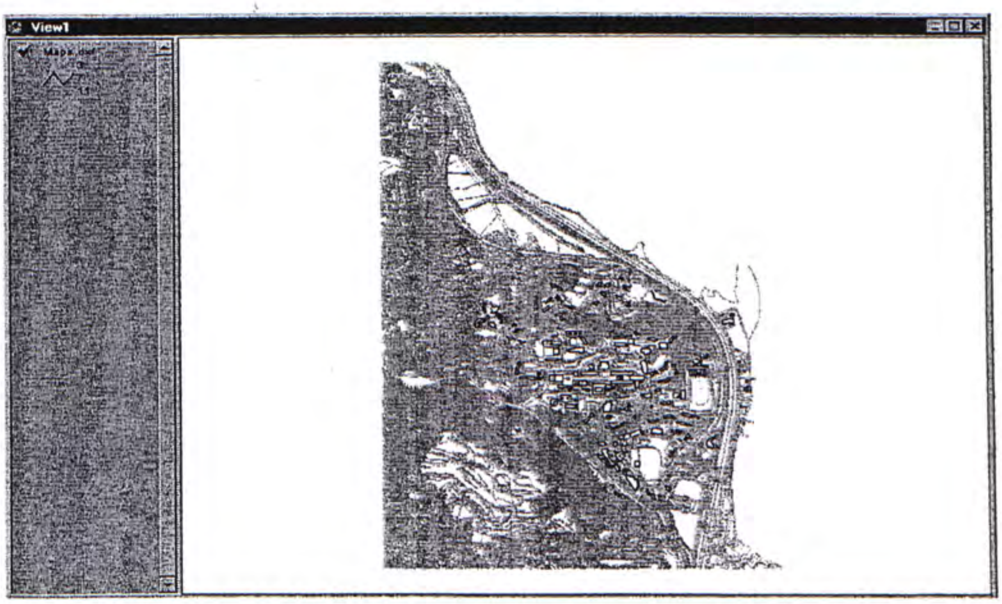


Figure 5.2: the raw .dxf drawing of the whole CUHK campus

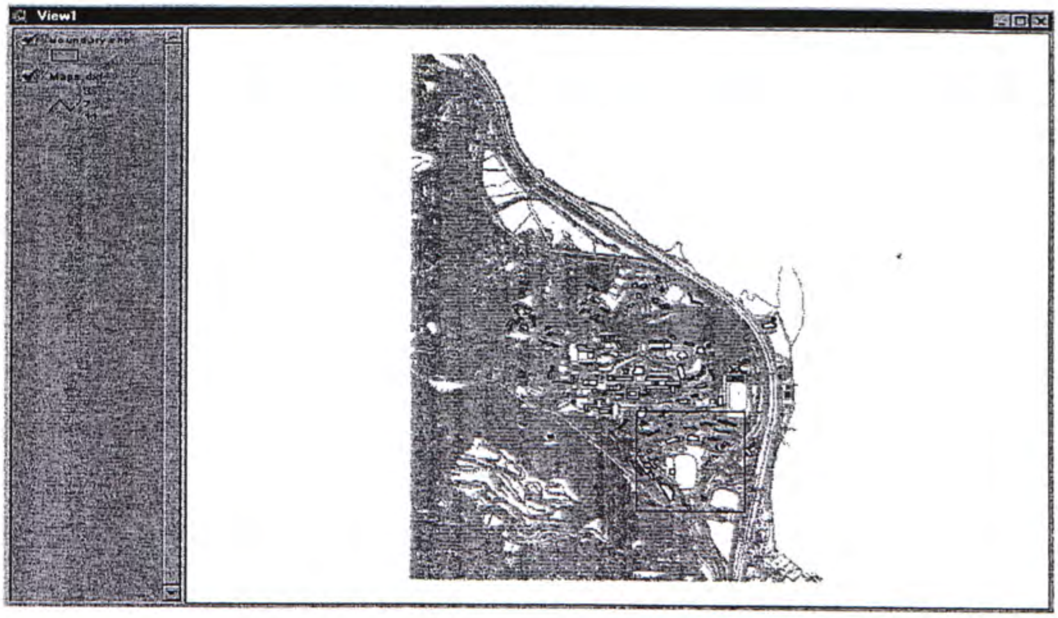


Figure 5.3: The bounding box of the research area—Chung Chi campus

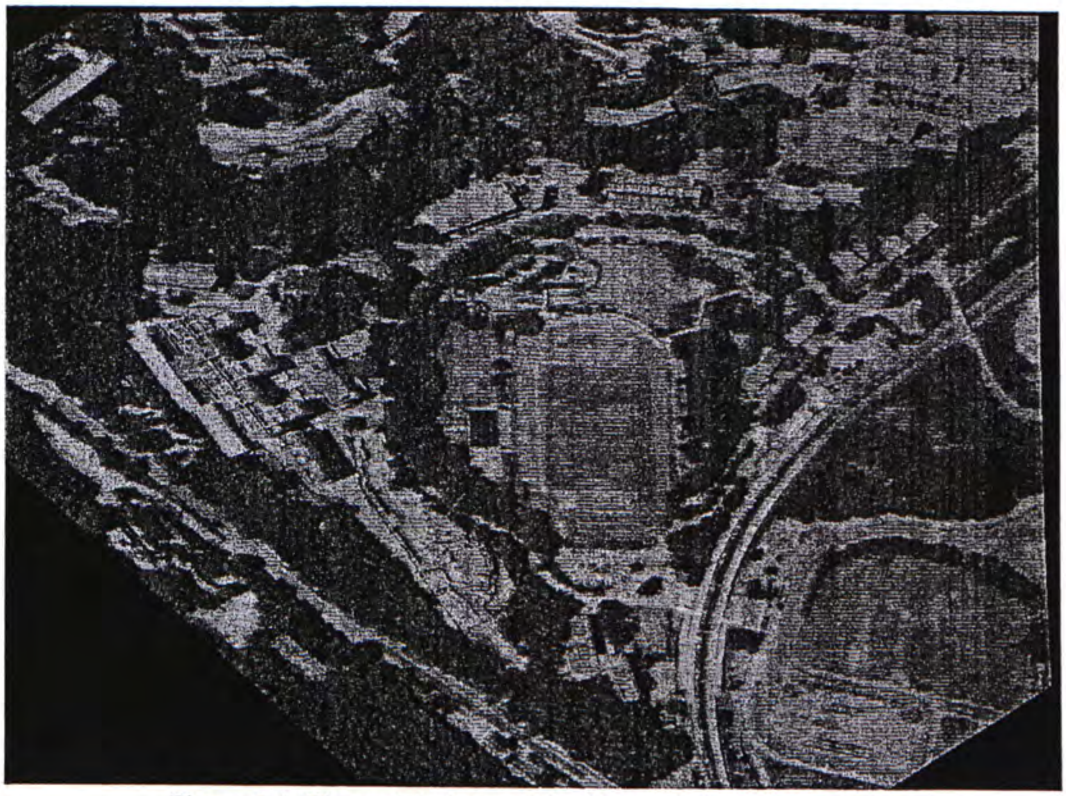


Figure 5.4: The aerial photo of the Chung Chi campus

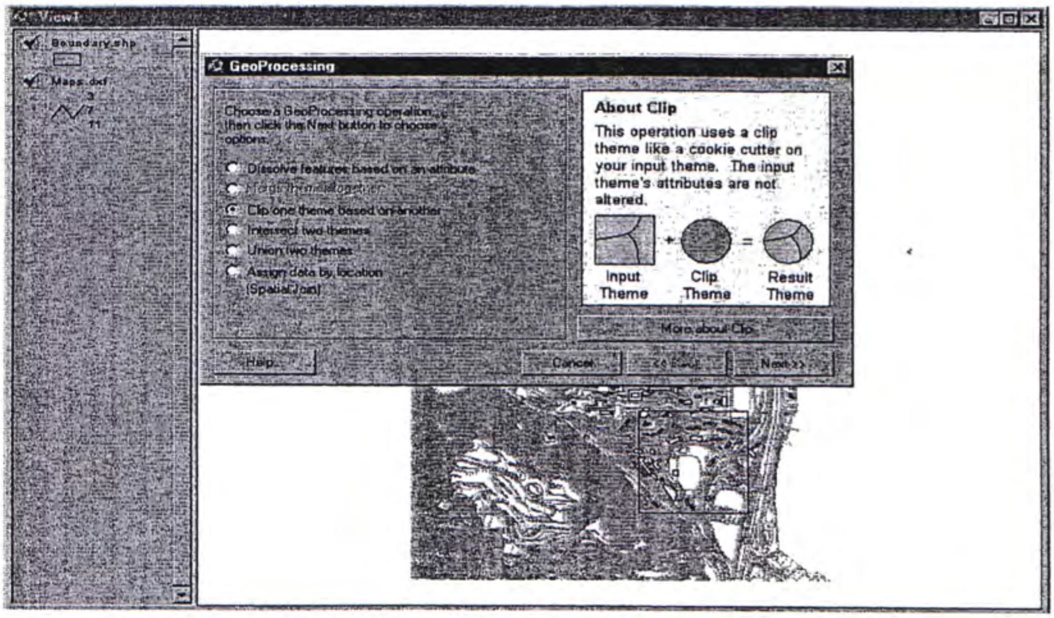


Figure 5.5: The intersection operation to isolate the Chung Chi campus

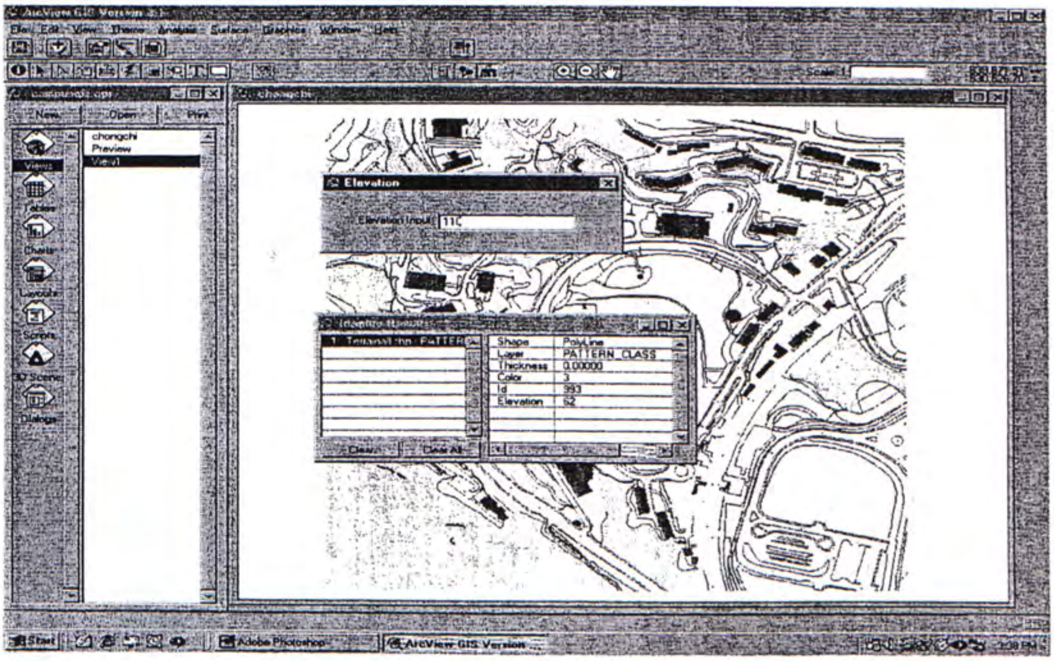


Figure 5.6: Assign the elevation value to each contour line

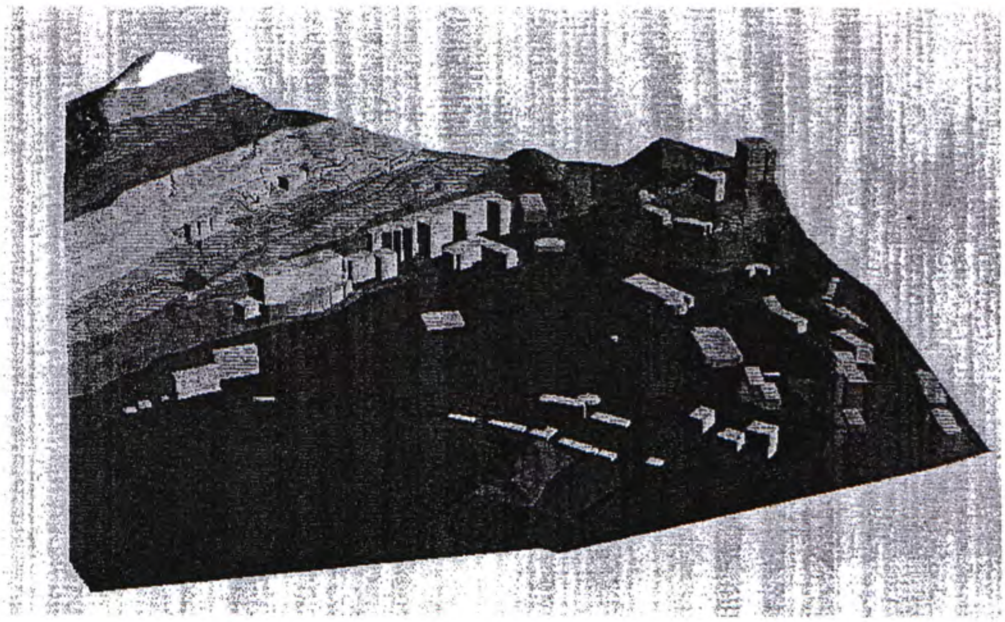


Figure 5.7: The draft 3D model exported by the GIS

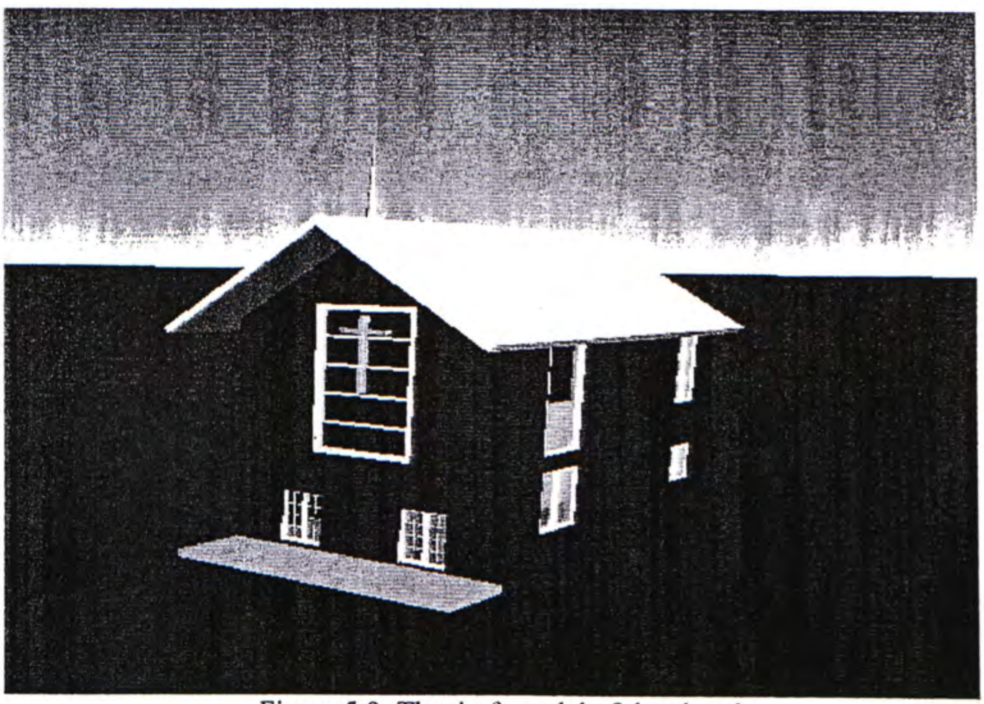


Figure 5.8: The draft model of the church

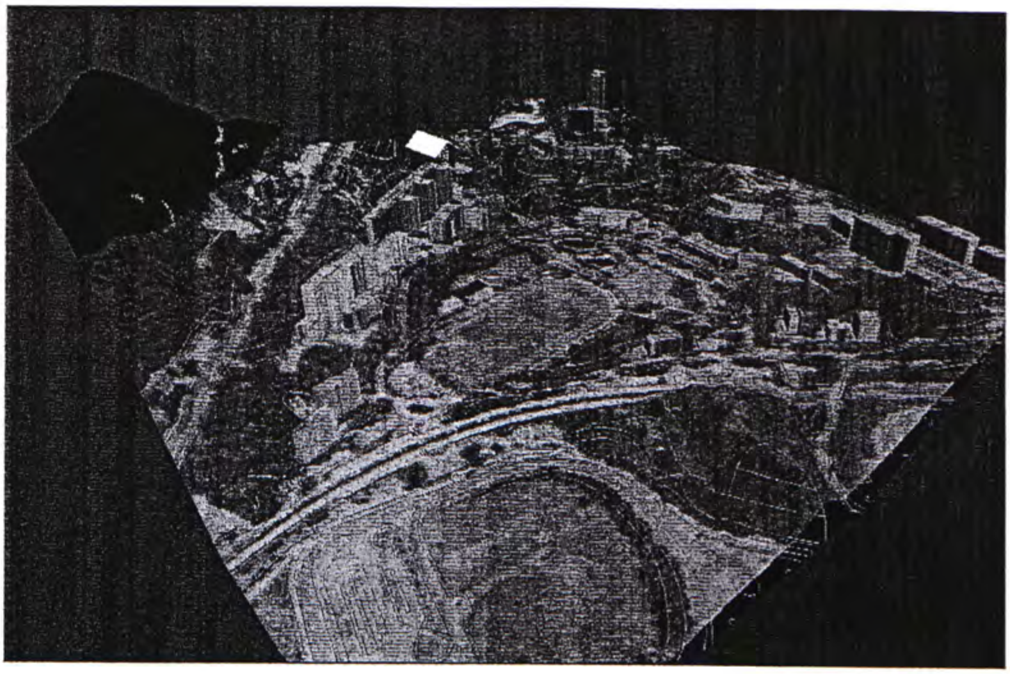


Figure 5.9: The integrated model of the Chung Chi campus

The limited scope of the simplified Chung Chi campus test case consumes not too much memory- the whole scene only occupies about 14.4MB. So, the level of detail (LOD) is also not applied here. In effect, I modeled only one level of detail. As a prototype, I used a model of the Chung Chi church to represent the concept of the model integration in the 3D simulation.

5.3.2 Retrieving the landscape themes

In GIS, the spatial database management system can only manage three types of spatial objects: point, polyline, and polygon. All themes can be described only by some combination of these types. However, the original data includes only the outlines of spatial objects. The graphic information should be classified first. Thus the linear description of the spatial objects can be fetched. To retrieve the spatial objects of the polygon type, the topology operation of GIS is utilized to connect the related lines into polygons. Figure 5.10 illustrates using the spatial query on the layer to separate landscape themes from the merged drawings.

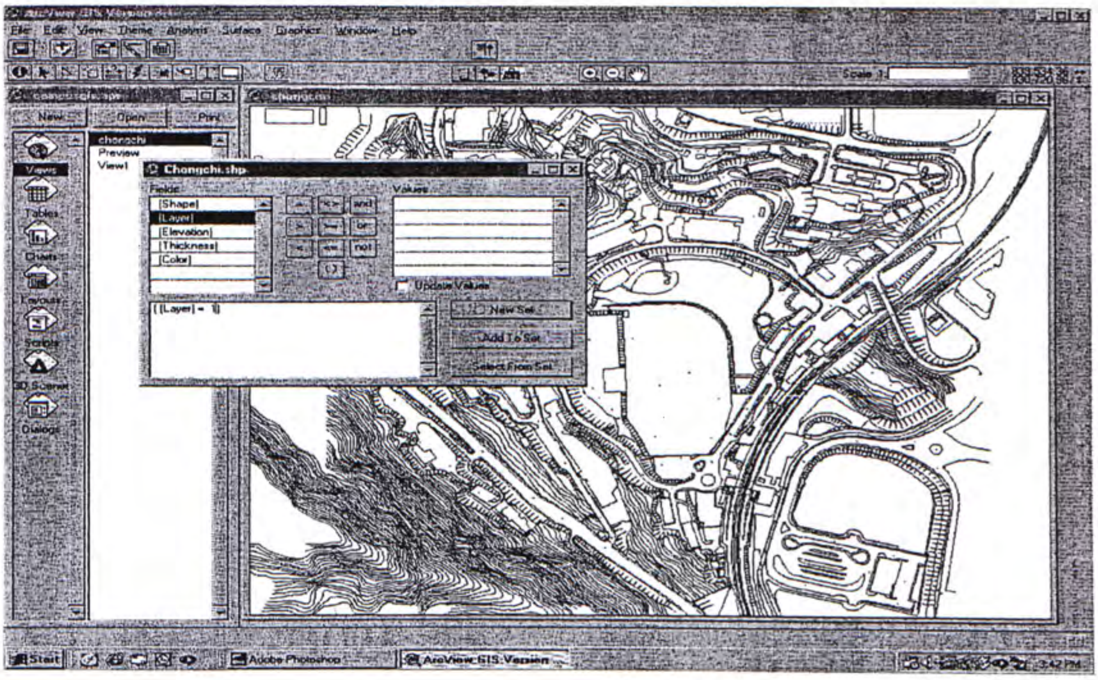


Figure 5.10: the separation of themes from the merged drawings

5.4 Public oriented user interface design

The following figures illustrate the user interface on the client end. Figure 5.11 shows the coordination of the GIS map and the 3D simulation. The view position and view field is overlaid on the map. It is intended to reduce the negative psychological effect of disorientation when navigating in the virtual scene. Such disorientation will interfere with the assessment of the urban landscape.

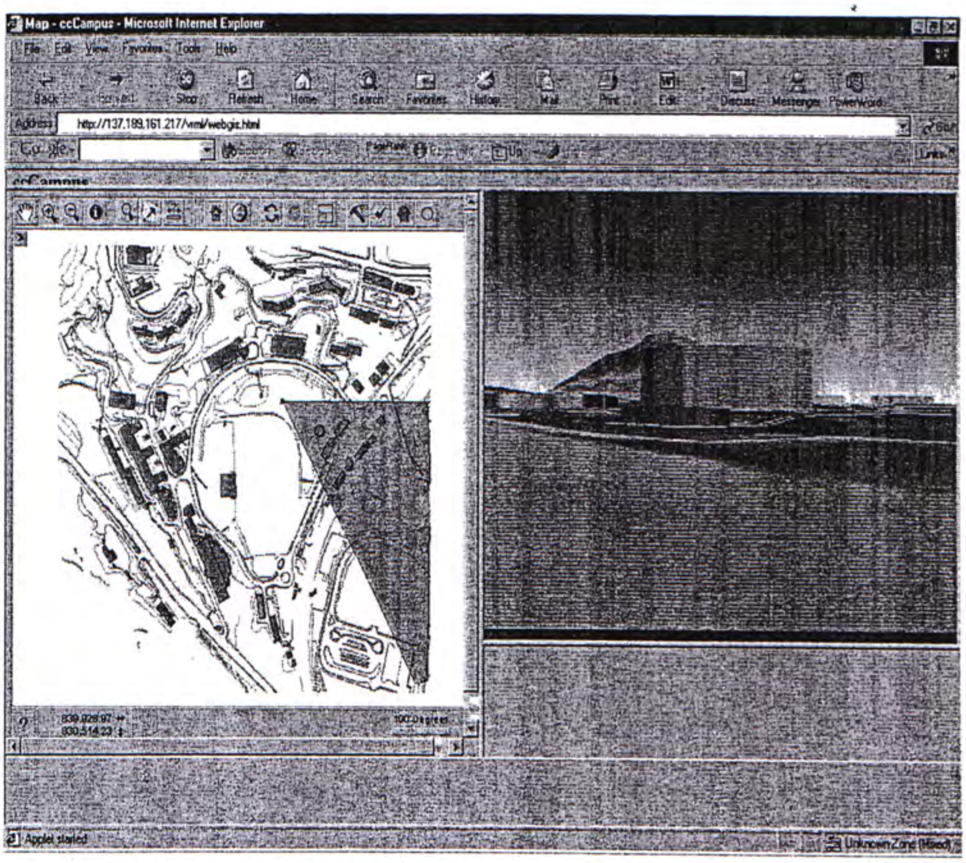


Figure 5.11: Transforming the view area from the VRML environment onto the GIS map.

Figure 5.12 illustrates the pop-up panel in the browser to let the user set up the parameters for the viewpoint. Because the position has been pinpointed by the user's click on the map, the user just needs to specify the height of the viewpoint, and the angular limits to the view field.

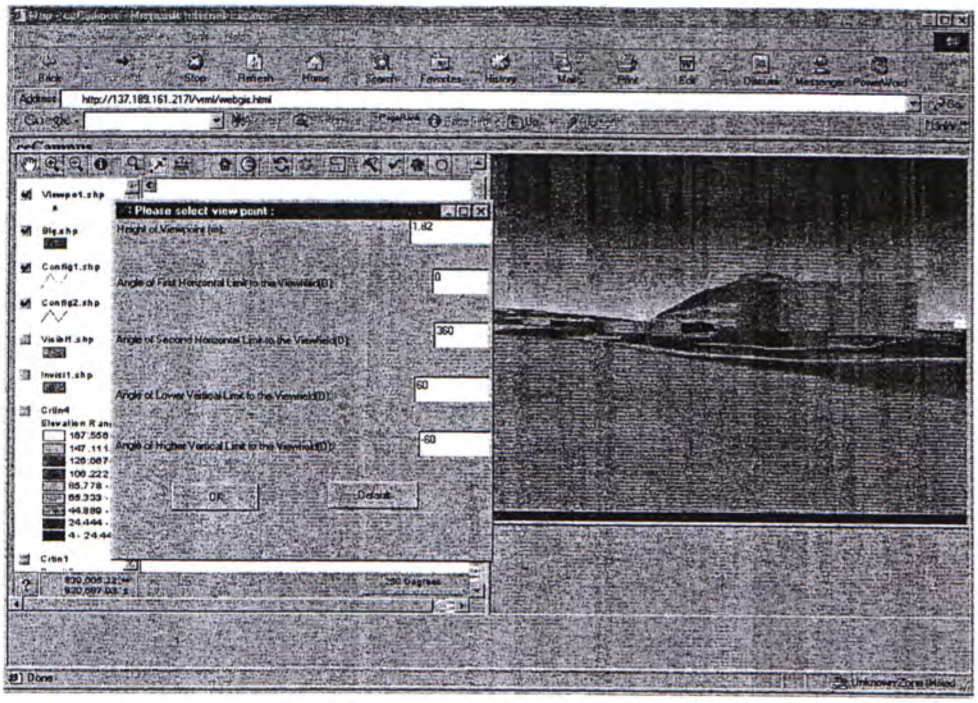


Figure 5.12: Panel for viewport parameter specification.

In Figure 5.13, the user draws a line on the map to represent the view corridor. The height of the fly route along the view corridor will be same with the value of the viewpoint set up before. However, the orientation of the view field will be adjusted automatically along the route when flying. The viewpoint floats on the route as the animation flows. The view corridor is also transferred into the server and stored in the GIS database as a specific theme.

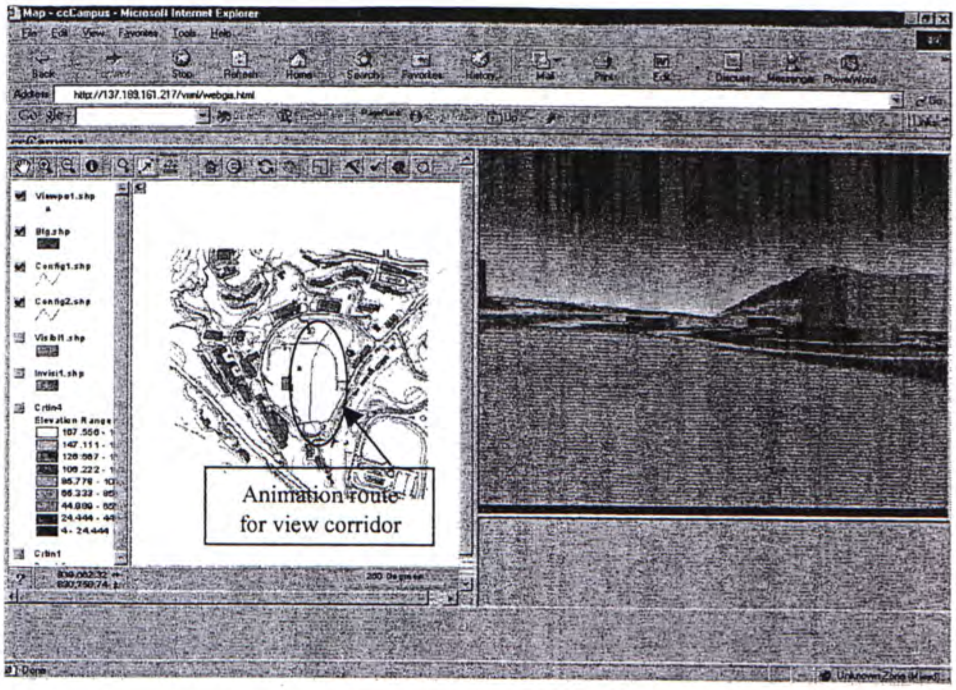


Figure 5.13: Setting up a tour route in the GIS and triggering the animation in VRML.

Figure 5.14 illustrates how to use the set operation panel. The panel is composed of three list choices. The first choices give the operation type: intersection or union. The second and the third choice show the two operands of the operation. When the user clicks on the OK button, the operation type and names of the operands will be packed into a CGI request and sent to the server end. The GIS server accepts the request, processes it, and generates the result. The MapCafe on the client browser will be notified to fetch the result and display it.

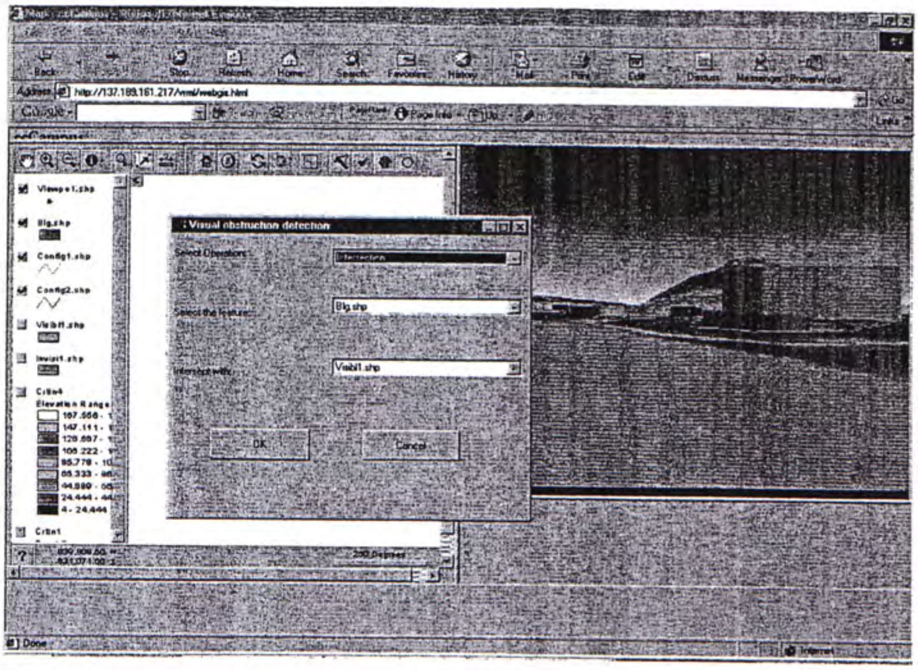


Figure 5.14: Control panel for intervisibility analysis of interesting features.

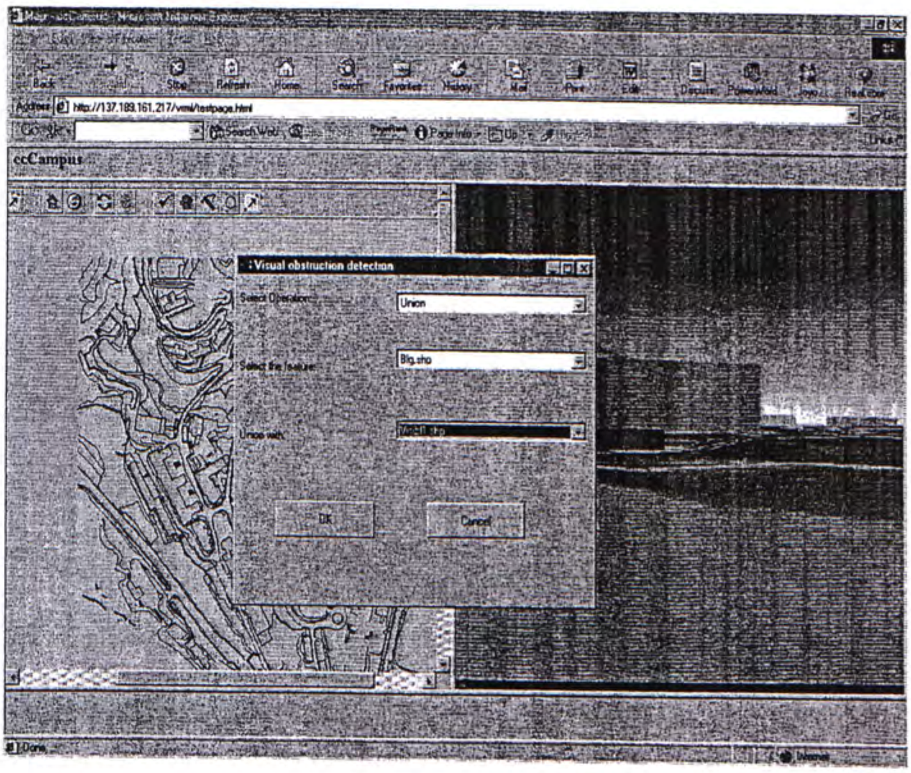


Figure 5.15: The union operation

As stated before, the virtual collaboration in this system is not only between the professional and public, but also among the public. Of course, the professionals can also log on the system and participate into the web-based assessment as a member of the general public. Here the professional may specify those designers or planners who propose the development. The spatial query panel and the assessment panel are developed to mitigate the public unfamiliarity with the web based GIS and the concept of the spatial query. The spatial query panel is shown in Figure 5.16. The operation of the user on the panel is automatically transcribed into an SQL styled query clause. This aims to help the user to comprehend the semantics of the operation. For example, if the user wants to retrieve the intervisibility impact on a specific theme from a given viewpoint, he just needs to choose the "Visible Area" from the selection list in the first field, and choose the theme from the selection list in the third field. When the OK button is pressed, the query clause will be generated. If the user also wants to add some notation on the query clause to aid his comprehension, he can name the result by entering the name into the text area after the "Name It" label in the second field. The analysis is based on the current viewpoint, which must be specified before hand. In Figure 5.15, the clause generated by the panel is "Select Visible Area Name it Area1 from Blg.shp what if view from the predefined viewpoint and describe the result as the most favored place". Figure 5.17 illustrates the query result. Figure 5.18 illustrates the virtual community by online communication. A participant can log onto the chat room using an alias name. He can view all messages in the text box after the All Messages label. He can also send his own message and give it a subject. This kind of online communication aims to contribute to the collaboration among the public. Figure 5.19 demonstrates the user feed back for the visual impact. The user should give an alias name that will be utilized to distinguish him from others in the assessment. He gives his assessment on the visual impact by typing his evaluation into the text field after the "Assessment on scene" label. The "when I" label is used to clarify the situation for his evaluation. He can view the scene from a predefined viewpoint or walk along the view corridor. The participant has to give his explanation for this evaluation. That information aids the designer or planner to determine the root of any negative impact and may also give some indication of the mitigation measures. In the illustrated case, the user judged the development to have a negative impact on the original scene as viewed from the selected point. He stated the reason for his assessment: "the building destroys the skyline of the natural scene."

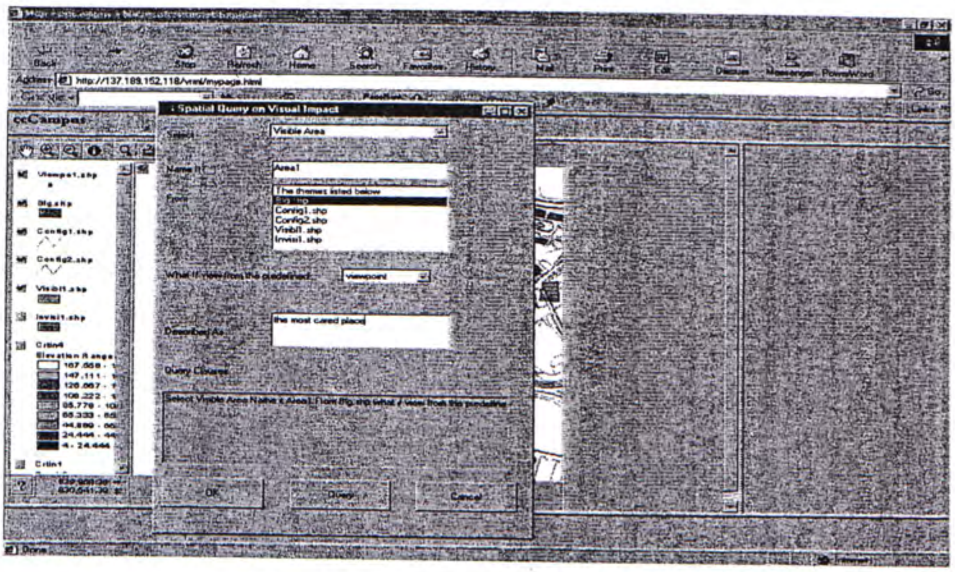


Figure 5.16: The spatial query panel on visual impact

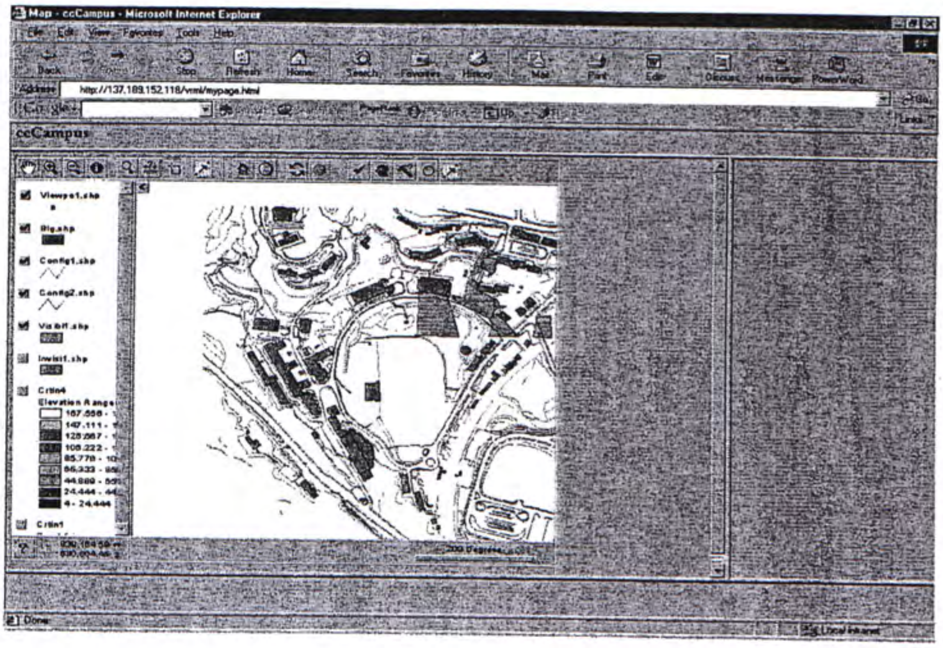


Figure 5.17: The query result of the visual impact

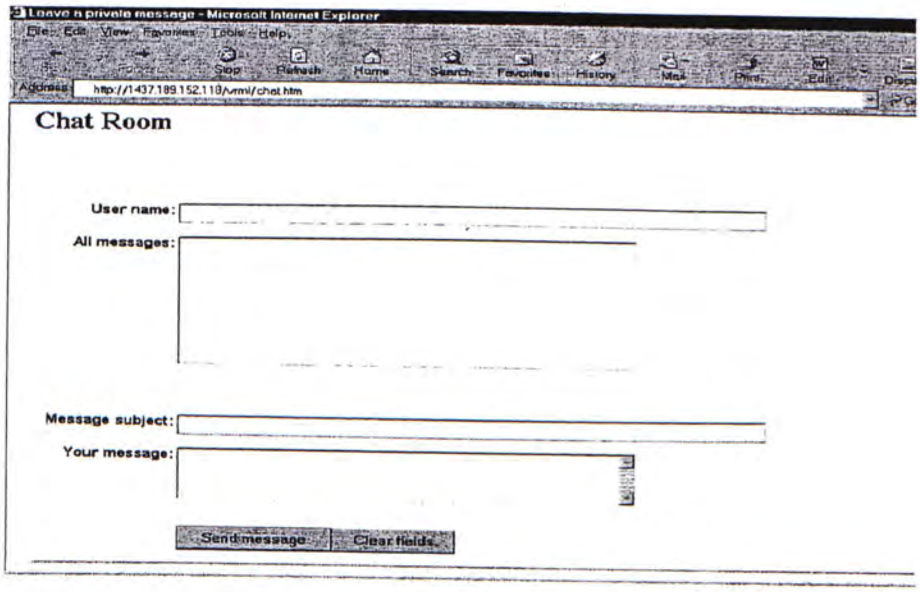


Figure 5.18: Chat room on line.

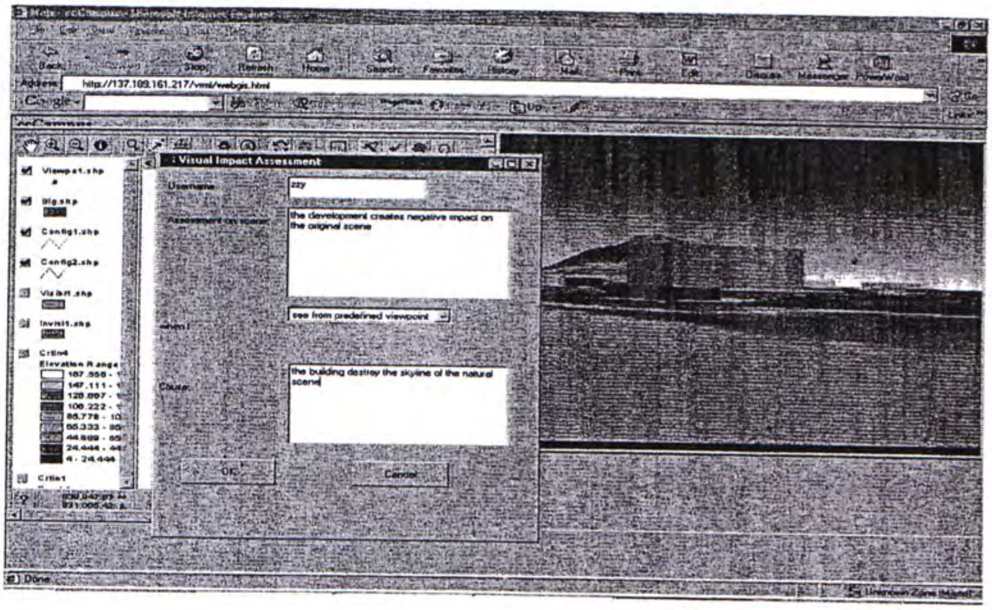


Figure 5.19: User feedback for visual impact assessment.

5.5 Participation log

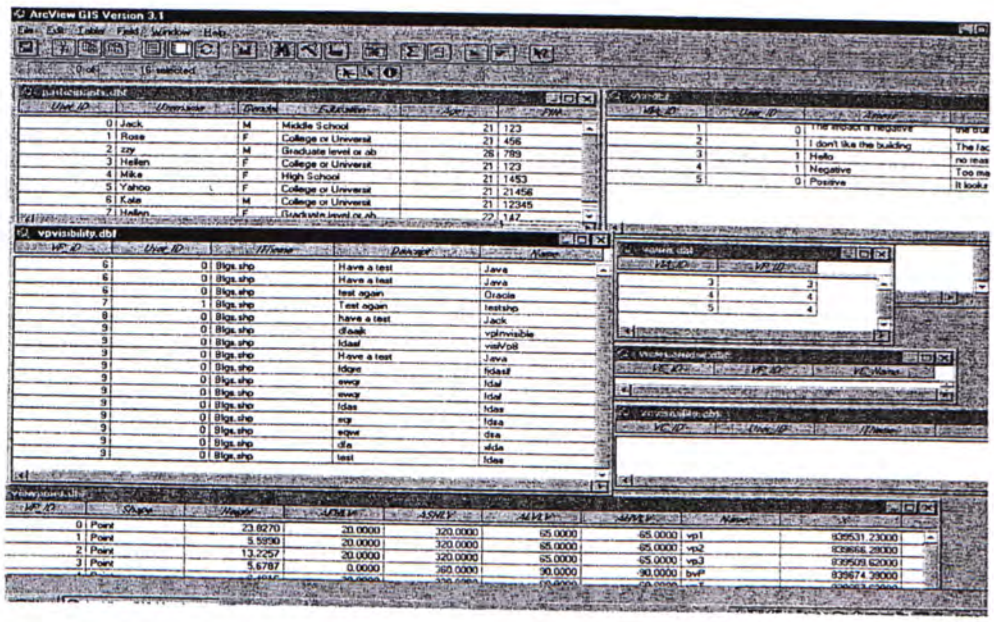


Figure 5.20: Public participation log

As mentioned before, the Figure 5.20 only demonstrated the concept of the public participation information management. The privacy protection is overlooked here.

CHAPTER SIX

CONCLUSION

In this thesis research, a specific web based three-dimensional simulation is integrated with a self-customized web based GIS system to facilitate people's participation in the urban landscape planning process. The motivation for the system design originated from the practical requirements of urban landscape management. This wants public participation, especially when it comes to the visual impact assessment. Before the construction of a project, planners may have to expose their design to the public, detect the possible negative visual impacts of the development, and negotiate with the public to mitigate them. The system design explores web based landscape simulation, visual impact identification from new development, and mechanisms for virtual collaboration on line between the planners and public for the urban visual resources management. The feasibility of such mechanisms requires more applications of the proposed system into the actual planning projects. New technology brings new channels for communication between planners and the public. In this specific web based system, public participants are empowered to view the prospective landscape after development, assess its visual impact from both intervisibility and amenity angles, and express their opinions on the specific Web based questionnaire. Planners or some other professional people can review and qualify people's assessment on the visual impacts, to determine the real causes of the negative visual impacts from their design. The virtual collaboration is implemented by the system's user interface, processing distribution, and database design.

The thesis research explores the feasibility of developing a Web based 3D simulation tools for urban landscape assessment research. For the quick prototyping considerations, the VRML modeling is utilized here. However, there are great limitations of applying the VRML to simulate the real urban landscape and make it run on the Internet. The huge scale and the delicacy of the urban landscape require the modeling of the urban landscape not only the vividness of the modeling, but also the flexibility of Level Of Detail. However, the data structure of VRML only allows the LOD to be utilized statically in the modeling stage. The machine cannot generate the proper LOD dynamically according to the scale, the complexity of the models, the viewpoint characteristics and the network traffic. Because the predefined LOD in the modeling would inevitably bring the problem of consistence control and redundancy if there exist component updating of the urban landscape models. That limits the application of Web based urban landscape simulation. The breakthrough may exist in the data structure research of the 3D modeling.

The participation log shows the management of public participation information. The participants' information is also stored in database. Because the case study is only for academic research purpose, the privacy protection of the participants is overlooked here. All participants demonstrated in the database are only some virtual players of the system. It is only for the reference of the preference research of the urban landscape. Others cannot trace those records back to the corresponding participant. The more dedicated system design should consider the privacy protection of the participants.

In the theoretical aspects of my further research, the public preference of the urban landscape may be explored. In the technical aspect, the prototype system can be enhanced in the following aspects:

1. Information processing

As mentioned before, the system is proposed to bridge the professionals and public in the urban landscape planning and assessment. On the current level, the system is able to gather the public participation information of the visual impact assessment of urban landscape. The gathered information should be utilized by professionals to aid their analysis of the public preference of the urban landscape. Another set of tools should be developed for professionals to be able to reconstruct the views defined by public participation information. Some extra spatial statically analysis tools should also be developed to facilitate professional analysis. For example, they may be interested at the most visual sensitive areas. That can be determined by the number of the viewpoints in a given area.

The graphical user interface of the proposed system should also be enhanced for better information interaction. Even though in the system design efforts have been made to improve the public accessibility of the Web based system, it cannot be said that it's sufficient. The actual application of the system may raise more concrete specifications for the graphical interface design.

2. How graphical simulation quality affects the perception of viewers

This may bring an ocean of problems. How to measure the distance between the simulation and the reality? Oh (1994) did some comparison of different kinds of landscape simulations. It was said that the image-based simulation is more vivid than the 3D modeling. But for an interactive system, the 3D modeling is more preferred. Is it possible for the technical evolution to mitigate the gap between the virtual reality with the real world?

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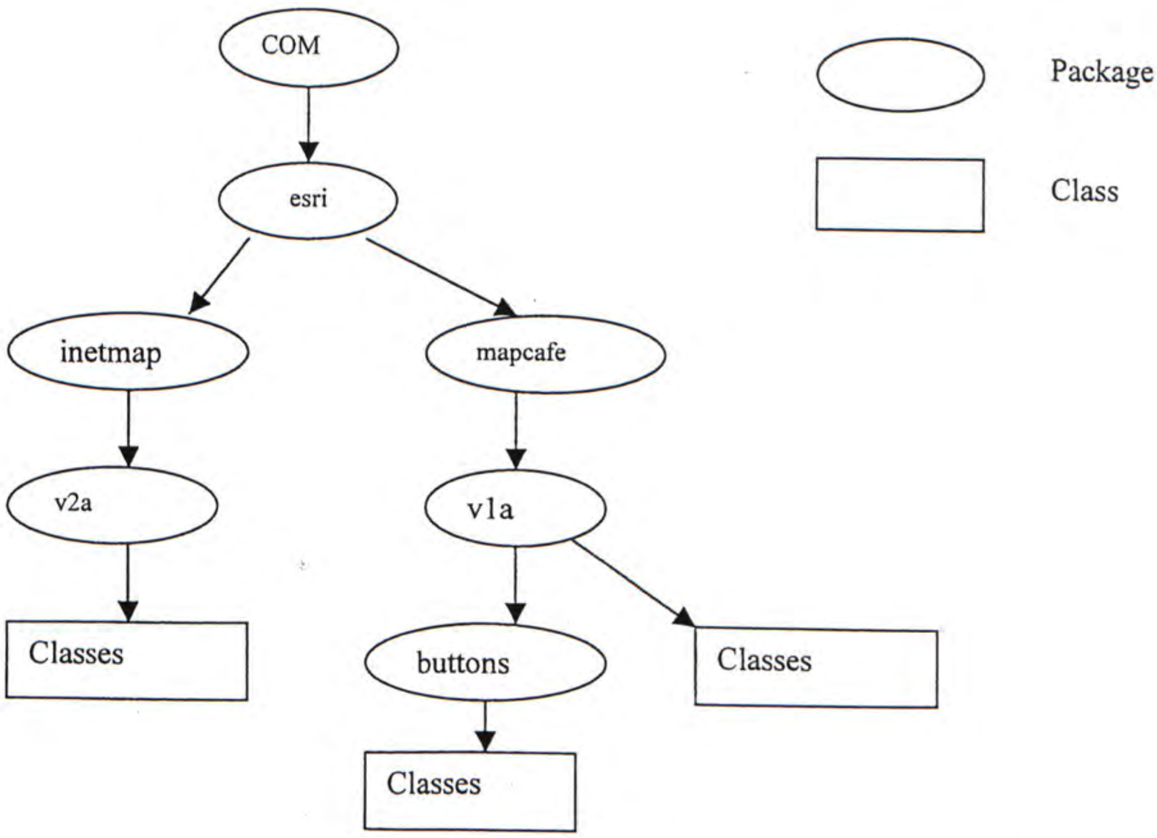
Appendix:

Main programming work of the prototype system

The programming work for the prototype system includes the customization of the MapCafe, self development of an application server to maintain communication between the VRML player and the MapCafe, and a lot of Avenue programming on the Arcview to accomplish the transactions on the server.

The hierarchy of the MapCafe packages:



In the package of COM.esri.inetmap.v2a, the classes are mainly in charge of the communication between the Web server and the client applet MapCafe. The classes in the package of COM.esri.mapcafe.v1a are mostly the graphical components of the MapCafe. The customization of the MapCafe involves both the new development of classes in the both above packages.

The communication server classes were defined in the Viewpoint package. The classes for VRML player to communicate with the MapCafe were also put in the Viewpoint package.

On the GIS server, a lot of Avenue programming work was done to trigger the Arcview to accomplish the corresponding transactions requested by the clients. For example, the user may want to do the spatial query on the intervisibility to a theme named Blgs.shp from a given viewpoint. The Avenue script named avinetmp.viaquery would be triggered to run after receiving the request from the client.

Package	Class name	Description
COM.esri.inetmap.v2a.	MapComm	Communication with Viewpoint.ApplicationServer
	MuReceiver	The daemon class to receive the message from the communication server
	EPolyLine	Allowing the user to draw a polyline on the map utilizing mouse
	MuProtocol	The application level protocol definition for the client/server communication
COM.esri.mapcafe.v1a.buttons.	mcPoint	A self defined point class
	perVar	A public class to maintain the information shares between the objects of MapCafe
	SetOpButton	The set operation trigger on the tool bar of the MapCafe
	SetOperations	The pop up panel for the set operation panel
	Tokenizer	The translation class to converting the received strings into meaningful messages
	VIAQuery	The spatial query on visual impact trigger on the toolbar of the MapCafe
	ViaQueryFrame	The panel to generate the spatial query on visual impact
	Viewpoint	The trigger to allow user to pinpoint the viewpoint on the map and set up the parameters on the button bar
	VPDlg	The panel for user to set up the parameters of viewpoint
	Viewshed	The trigger to do the viewshed generation on the tool bar of the MapCafe
	vpTrack	The trigger on the toolbar of the MapCafe to track the viewpoint in the VRML simulation
	vpTrackDlg	The dialog of the vpTrack
	VREngine	The trigger to retrieve the VRML into another frame of the same browser with MapCafe
	VRTFrame	The panel of the VRTrigger
	VRTrigger	The trigger on the tool bar of MapCafe to allow user make assessment on the visual impacts

Package	Class name	Description
Viewpoint	ApplicationServer	The application server to initiate the communication channels with both MapCafe and the VRML player
	Commbined	Combining communication channels of the MapCafe and the VRML player with the same IP address as one peer to facilitate their inter communication

	MuClient	The father class which inherited the Thread class to receive the messages from the application server
	MuDispatcher	Dispatching the combinations of the MapCafe and the VRML player into peers when there are multiple participants
	MuServer	The communication server for application server to construct a communication channel with the MapCafe
	VRComm	The communicator embedded in the VRML scripts to keep communication with the VRServer
	VRServer	The communication server for application server to construct a communication channel with the VRML player

The main self-developed or customized Avenue scripts for the proposed system on the Arcview include:

Script name	Description
Attrquey	The script referred by avinetmp.viaquery to do the query on the attributive information of selected theme
Avinetmp.getmap	Self developed script to send the names of the themes in the view into the choice of the set operation panel of the MapCafe
Avinetmp.getusers	Self developed script to send the usernames in the tables of participants into the choice of the registration panel of the MapCafe
Avinetmp.id	Customized script to empower user click on the selected theme to do the attributive information query
Avinetmp.init	Customized script to changed the definition of the MapCafe button bar or tool bar
Avinetmp.pincheck	Self developed script the check the pin received from the client end
Avinetmp.registration	Self developed script to let new user sign up
Avinetmp.setoperation	Self developed script the do the set operation according to the requests received from the client
Avinetmp.testmap	Self developed script to send the theme names of the view into the choice of the visual impact query panel
Avinetmp.viaquery	Self developed script to analysis the request the spatial query of the visual impacts and trigger the proper transaction
Avinetmp.viassessment	Self developed script to analysis the request the visual impact assessment and trigger the proper transaction
Avinetmp.viewshed	Self developed script to accomplish the viewshed analysis according to the request received from the client end
Avinetmp.vptrack	Self developed script to save the tracked viewpoint into database
Avinetmp.vpupdate	Self developed script to update the viewpoint theme according to the parameters received from the client end
Avinetmp.vr	Self developed script to process the request of VRML retrieval from the MapCafe
Avinetmp.vsmap	Customized script to update the map of the MapCafe
Avinetmp.vsmapmake	Customized script to make up the map