VISUALISATION IN ARCHITECTURE AND PLANNING

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This paper discusses and illustrates advances in the visualisation of man-made and natural environments and suggests how these advances will affect the practice of architecture and planning. Particular emphasis is given to the relationship between modelling the formal and the functional attributes of man-made objects a and to the mixing, visually, of such objects with the natural environment.

1. THE APPRAISAL OF FORM AND FABRIC

For some years now the visual impact of buildings on the landscape has been a contentious issue at many public planning inquiries. This reflects the underdeveloped state of objective visual appraisal, particularly in the clear presentation of the harmful and enhancing effects of building proposals on the local environment. Notably, the accuracy and realism of traditional visual assessment methods has been called into question. This must be of concern to the environmental design professions, since Environmental Impact Analysis will continue to place significant demands on the rigour of assessment procedures. Thus, at a time when rural landscapes are coming under increasing pressure from industrial developments, project decision makers cannot afford to make judgements on insufficient, inappropriate or inaccurate visual evidence.

This paper is concerned with a new generation of computer-based models which predict, accurately and meaningfully, the visual impact of buildings and other constructions on their urban or rural environment. As such they form part of the increasing repertoire of CAAD techniques which allow designers to appraise, and thereby select from, alternative design options. The computer-based appraisal of design options may be seen in systems terms (Figure 1). Typically, CAAD software will predict, for any design hypothesis, a wide range of performance consequences - economic, functional, environmental. Input to the model, ie the design hypothesis, consists of the proposed form (ie geometrical layout) and fabric (ie constructional choices) of the building. As it turns out, this input data is every bit as relevant to the visualisation of the building as it is to the prediction of its cost, energy consumption and operational efficiency.

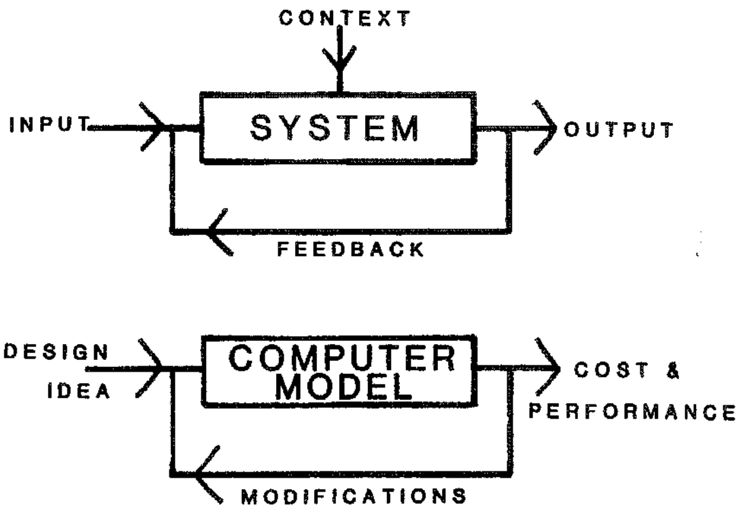

FIGURE 1 A Systems View of Design

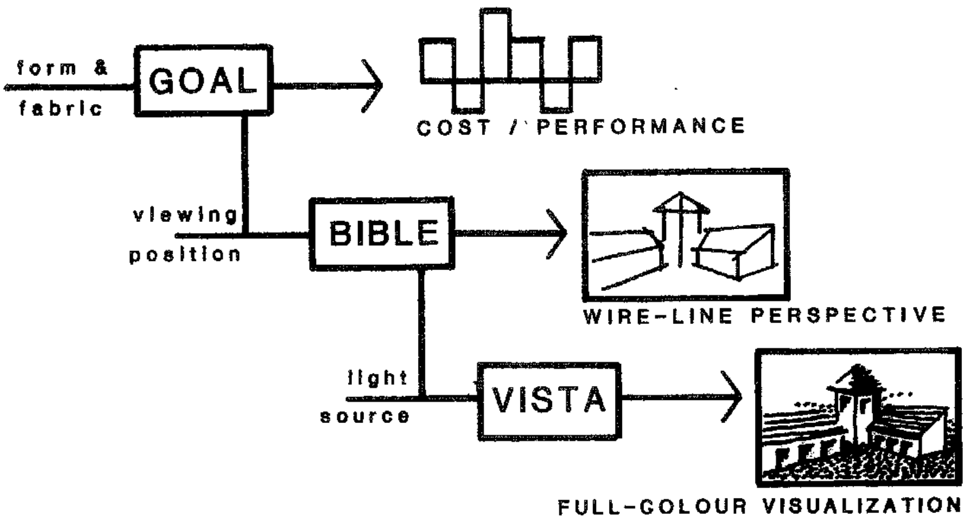

FIGURE 2 Inter-relationship of GOAL, BIBLE and VISTA

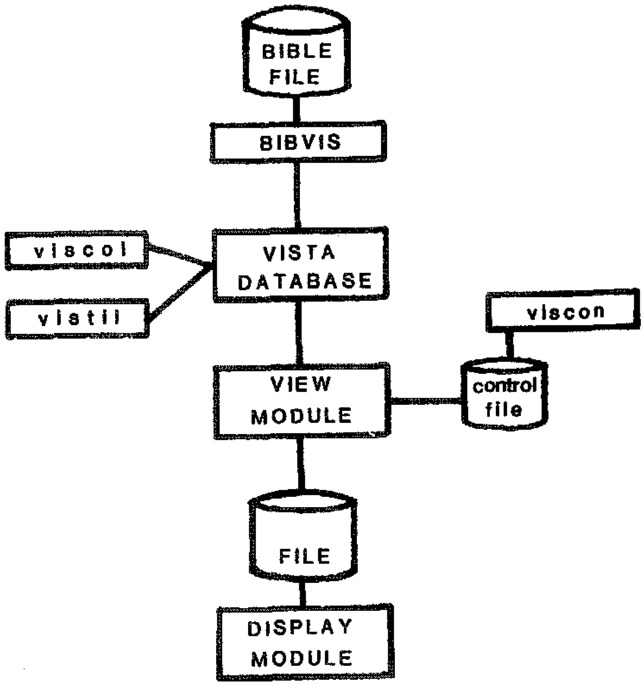

FIGURE 3 The Structure of the VISTA System

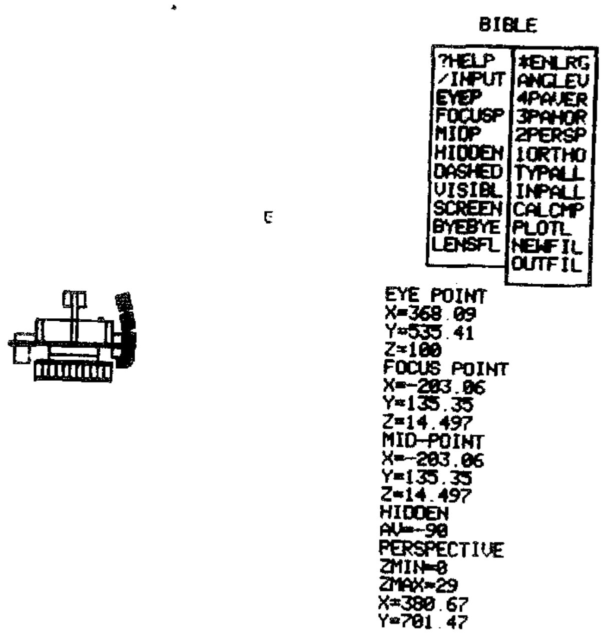

FIGURE 4 The Interface with the Program BIBLE

It is thus possible, to create a suite of computer programs, each operating on a shared description of the building form and fabric, which allows appraisal of the aesthetic qualities as well as the economic, functional and environmental qualities of the building. Such a suite is represented in Figure 2.

The program GOAL (General Outline Appraisal of Layouts - described in Aicographics 82) outputs a profile of cost and performance measures; the building geometry is passed from GOAL to BIBLE (Sussock, 1982) which generates wire line perspectives from any viewpoint; BIBLE, in turn, passes the geometry to VISA (Stearn, 1982) which generates, for any sun position, fully coloured, textured and lit perspectives.

2.0 PROGRAMS FOR VISUALISATION

The programs BIBLE (Buildings with Invisible Back Lines Eliminated) and VISTA (Visual Impact Simulation, Technical Aid) offer the designer a two staged approach to visualisation. The first stage is the production of wire line perspective views; these may be perfectly adequate where issues of visibility predominate or where the object has a skeletal structure (eg electricity pylons). The second stage is the production of fully coloured textured and lit perspectives; such views are necessary where issues of visual quality predominate.

2.1 Bible

The user interface of BIBLE (Figure 3) is designed to be as easy for the inexperienced user as possible, without sacrificing the capability to specify arbitrary projections. This is achieved by four features.

(a) Fail-soft design: any invalid or wrong input produces an English language error message, apologising for the program's inability to understand the input provided and explaining what sort of input was expected, or what options were available to the user at that point.

(b) Graphical specification of view point. This allows the user to point out on a displayed plan view to a place in the vicinity of the building(s), and in effect, ask 'What does it look like from here?'.

(c) Use of default parameters: all the view control parameters have default values computed by the program for each data set as it is read in. Thus it is possible simply to read the data file and immediately call for a view, and get a meaningful picture.

(d) A command menu on the screen gives the user a visible reminder of what he can do without verbose prompts, and more detailed information can be obtained by selecting the HELP command.

The user-specifiable view parameters and default values are as follows:

(a) the EYE POINT from which the scene is viewed may be any point (X,Y,Z) inside or outside the region containing objects. X and Y may be specified graphically. The default is a 'long way away' in the -X,-Y, +Z.

(b) The FOCUS POINT which is the other end of the line of sight may be any point (X,Y,Z). X and Y may be specified graphically. The default is the middle of the scene. The focus point may be moved in order to obtain two-point perspectives or views of off- centre parts of the scene.

(c) The MID POINT (of the resulting picture) may be any point (X,Y,Z). X and Y may be specified graphically. The default is the middle of the scene. The mid-point is normally set the same as the focus point, but it may need to be different for two-point perspecitves or non-orthogonal parallel projections.

Hidden lines may be removed (which is the default), drawn dashed, or left in. The projection may be perspective (by default) partially perspective (paralell verticals, parallel horizontals) or orthogonal. Output may be to a display file to the terminal screen or to a plotter scaled to A1, A2, A3 or A4 size; output device selection is dynamic and may be changed between pictures. A major facility offered by the program is that of producing views which can be automatically superimposed onto site photographs. The user simply specifies the camera position, the focal length of the camera lens and the enlargement of the photographic print; the resulting view is correctly scaled, positioned and proportioned for the photomontage.

2.2 VISTA

VISTA may be classified by describing it as a 3-D colour perspective package with hidden surface elimination; it may be used to model any artifact composed of planar surfaces. Although wireline perspectives, as produced by BIBLE, can be very valuable aids to visualisation they lack realism and require more interpretation on the part of the user. The use of colour to fill the surfaces improves the 3-D impression, particularly if the surface colours are predicted by a simple lighting model and even more so if shadows are generated.

The outline structure of VISTA is shown in Figure 4. The VISTA database contains a hierarchically structured definition of the geometry of the model. This definition is similar to the BIBLE geometry definition, the model is composed of Bodies which contain planar Faces. In addition to the BIBLE type description VISTA allows another level of detail to be associated with each Face, these are known as Tiles, and may be used to model areas of different colour or features such as windows and doors on the face of a building. Because of the close relationship between the geometric data required by both BIBLE and VISTA, the VISTA database is created from a BIBLE data file by running the interface program BIBVIS. The reasons for creating VISTA geometry as a BIBLE data file are as follows - a large number of examples already exist in BIBLE format; programs for creating BIBLE geometry already exist; if the geometry exists in BIBLE format then it can be run by both programs. In addition to the geometrical description of the model the VISTA database also contains the colour details for each Body, Face and Tile in the model.

Shadows are created by running the hidden surface algorithm using the light source position as the eye position, the visible areas are illuminated by the light source and the invisible areas are in shadow. The visible areas known as Patches, are stored in the database and may be retrieved on subsequent views to display the shadows from the defined light source. In the current implementation of VISTA up to ten shadow studies may be stored in the database and up to five shadow studies may be retrieved for any view.

One of the most important aspects of a package such as VISTA is the interface between the user and the colour model within the package. This interface is becoming increasingly complex as the colour pallete of the latest colour terminals becomes very large (typically 16.8 million). Since most colour devices use the RGB colour model for defining colours most lighting algorithms have evolved around that model, VISTA is no exception. Although the RGB model is very easy to understand, most people find it very difficult to express colours in terms of Red, Green and Blue. Because people with different backgrounds, in terms of their use of colour, will be familiar with types of colour model, the colour interface routine VISCOL has a number of different colour models from the user may make his choice of colours. These models are as follows: Red, Green, Blue (RGB); Cyan, Magenta, Yellow (CMY); Hue, Lightness, Saturation (HLS); Hue, Value, Saturation (HVS); British Standard Colours. Each of the selection modes allows the user to view the chosen colour before entering it into the database. In addition to the variety of colour models other options allow the user to manipulate the colour space to give him a guide to accurate choice of colour, ie sections of constant hue from the HLS model. Another feature allows the user to create a file of colours and then retrieve from that set by name rather than by value, this ensures that the same colour is used throughout rather than use memory or guesswork to match colours. Another application of this feature is to use it to define the range of colours given by paint manufacturers.

VISTIL is the module which allows the user to create and manipulate Tiles. This is achieved by transforming the target face to a normalised view and then defining the Tile as a polygon either by cursor or by inputing as local co-ordinates, the Tile polygon is then transformed back into model co-ordinates and stored in the database. Tiles may be copied from face to face or from body to body either singly or in groups. An example of the use of Tiles to model texture effects is shown in Figure 7. This is achieved by using a special type of tile, known as a Grid Tile, which is repeated over the surface in question. Other definable parameters allow the user to randomize the colour of the tiles within a given tolerance.

The VIEW module is the heart of the VISTA package; it performs the perspective transformations, the hidden surface elimination and the colour rendering. It takes as input the description of the model as defined by the VISTA database and the required viewing and lighting parameters. The viewing parameters consist of the type of view required, ie bird's eye, camera, etc, and the eye and focus positions. The lighting parameters specify the position and spectrum of any light sources (in RGB) and whether any shadow studies are to be retrieved. The lighting model in VISTA allows the user to model the ambient, diffuse and specular components of any light source, and also to vary the ratio of ambient to direct light available from that source.

The output picture is written to a display file and not directly to a colour output device, this has several advantages the most important of which is that the VIEW module can be totally device independent.

3.0 CASE STUDIES

Visual modelling by computer in an urban context may include representation of the surrounding townscape in addition to the study building. Figure 5, featured earlier in Aicographics 82, shows the winning entry to a compeition for a Hilton Hotel (unbuilt) in Edinburgh. The townscape model was constructed photogrammetrically by digitizing points from aerial sterio pair photognaphs whereas the gemoetry data describing the proposed building were hand keyed alphanumerically. BIBLE is thus able to operate on the total data set - existing and proposed - generate the view from any position; Figure 5 gives the view from the Castle esplanade but views from any other vantage point are just as readily obtainable.

An alternative approach, of particular relevance when a building is to be placed in a rural as opposed to an urban setting, is that of photomontage. BIBLE allows the user to specify the camera position as the viewpoint; by keying in the focal length of the camera lens and the enlargement of the photographic print, BIBLE will generate a perspective view of the proposed building which is correctly scaled, proportioned and positioned for automatic superimposition on the site photograph.

Figure 6 shows the efficacy of this photomontage approach as applied to a second power station at Castle Peak on the Hong Kong mainland. This particular case presented a special challenge as the camera positions, many of them from the ferry or from a helicopter, were unknown; an additional program was written to triangulate back from recognizable topographic features to the camera locations. The accuracy with which the camera positions were computed was checked by including, in the BIBLE generated views, part of the existing power station.

Case studies in the use of BIBLF for photomontage work has led to refinements in the program and in the procedures. The current version takes full account, for instance, of the curvature of the earth's surface and the refraction of light, thus ensuring the highest possible degree of accuracy in the relationship of the building to its site.

In some design and planning situations it is not enough simply to locate the building on its site, as exemplified in Figures 5 and 6. Additionally, there is a requirement to predict the visual quality of the proposed development. Two recent examples of the use of VISTA to generate fully coloured, textured and lit perspectives are of interest.

Figure 7 shows one of a very large number of VISTA generated views of the French New Town of Dreux. The planners carefully specified a series of views which would correspond to the experience gained by someone walking through the environment. A video tape was then made from the separate images generated by VISTA to simulate the dynamic aspects of the 'walk-through'. A view selected from the series was awarded 'computer graphics image of the year' by the CADCAM Journal,

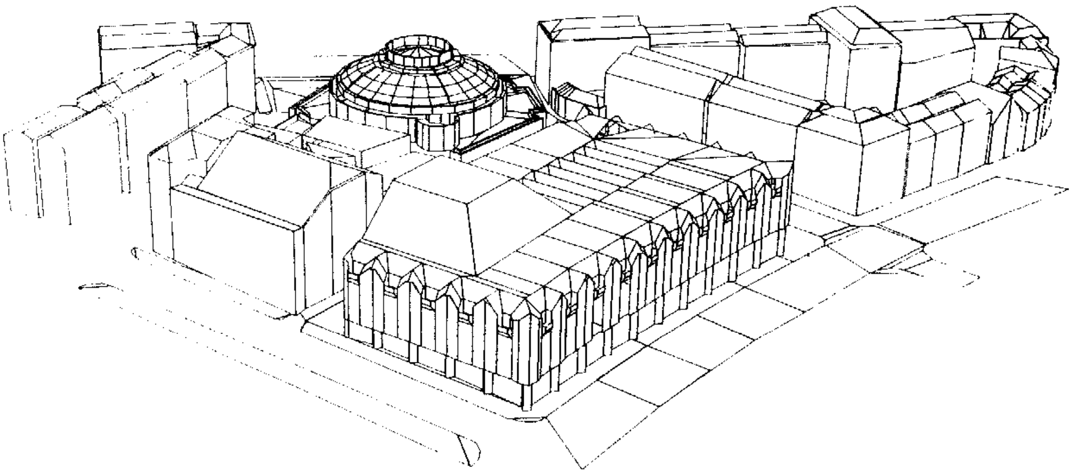

FIGURE 5   A New Building Shown Within an Existing Townscape

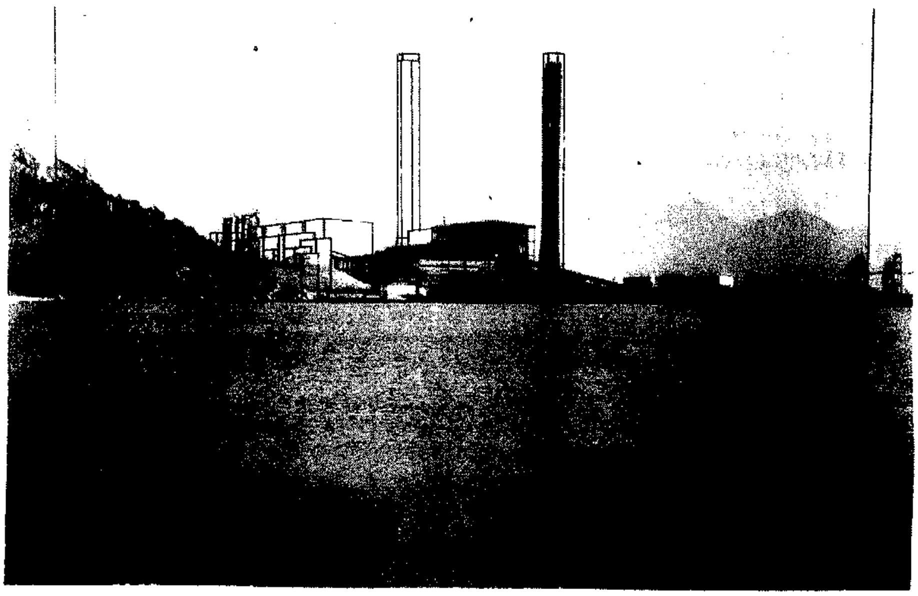

FIGURE 6   A Photomontage of the Castle Peak Power Station

More experimentally, VISTA has been used to model quite complex terrain. In Figure 8 the proposed site for a zoological garden is displayed.

Ultimately, the validity and usefulness of a modelling aid will be measured against its ability to predict reality. This retrospective visual appraisal of a building was intended to verify certain modelling features of the program VISTA. A particular view of the Architecture Building at Strathclyde University was chosen and the time of day and sun position recorded, in addition to the regular viewing parameters. The BIBLE geometry data file of the building was concerted to a VISTA database and surface colour specifications compiled. The predicted simulation was then generated on the AED512 colour terminal and compared with the actual view (Figure 9 a and b).

4.0 FUTURE DIRECTIONS

The new technology, particularly that associated with image grabbing and enhancing, holds out tremendous promise for effective visual impact analysis. Using these techniques the merging of the computer generated image with a video image of the site can be controlled and explored.

Maintaining the correct colour balance and quality of hardcopy reproduction from graphics terminals has, however, consistently proved to be a stumbling block in the presentation of accurate visual evidence, especially when building surface colours and textures are under examination. In the same manner, research dissemination in this field is fraught with reproduction difficulties; even within this paper uncertainty exists as to the fidelity of the colour graphics reproduced. Significant improvements in the copying and reproduction of colour computer graphics for visualisation in architectural design are required if the benefits of building detailed simulation models are to be properly harvested.

Many techniques for visual assessment are initiated in the later detailed stages of design work. In contrast, there is a greater need for methods and models to be developed and applied at the earlier outline stages of design, where the major visual design decisions are normally taken. Computer-based models seem best structured for continuous application throughout design from inception to completion, and beyond in terms of visual resource management in future planning and landscaping.

5.0 ACKNOWLEDGEMENTS

ABACUS gratefully acknowledges the support given to this work through grant aid from the Science and Engineering Research Council. A great debt is also owed to those architects and planners who, ambitious to provide clients with the most professional service possible, have collaborated in the work.

6.0 REFERENCES

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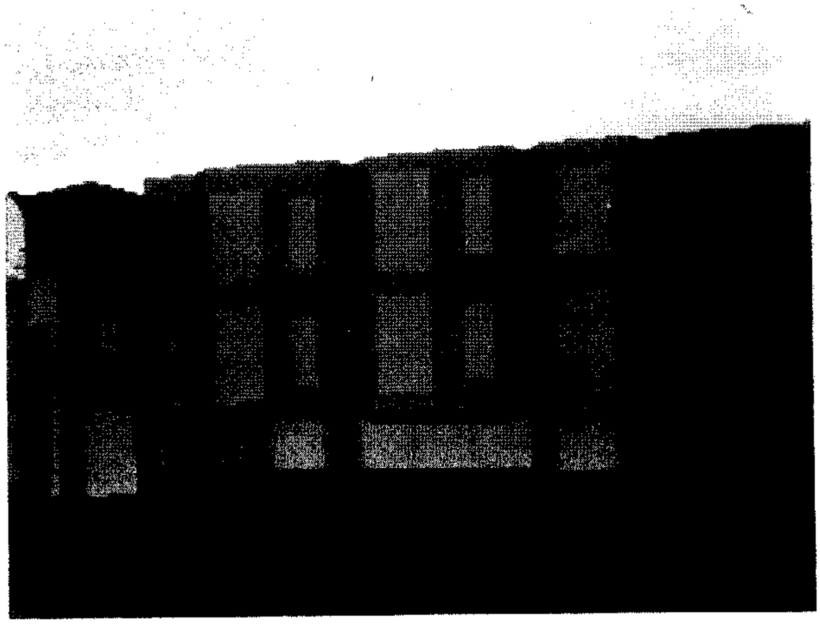

FIGURE 7 Visualisation of Part of the French New Town of Dreux

FIGURE 8 Visualisation of the Site of a Proposed Zoological Garden

FIGURE 9a Visualisation of the Strathclyde Department of Architecture and Building Science

FIGURE 9b A Photograph of the Actual Strathclyde Department of Architecture and Building Science