ON CAPTURING CONTEXT IN ARCHITECTURE

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ABSTRACT

Simulation of visual context in architecture, the environment that surrounds both building and observer, is an essential but problematic feature of realistic imagery. The complexity and detail of typical environments pose serious difficulties for computer modelling and photomontage techniques. The results are often simplistic, potentially misleading and incapable of representing many of the physical and perceptual relationships involved.

This paper describes an alternative methodology using imagery for the whole optic array at a specific location. It is mapped onto simplified geometric forms for the environment and combined with a computer model of the building proposal to produce realistic imagery.

INTRODUCTION

Computer simulation systems are being increasingly applied for realistic visualisation of architectural proposals [Larson & Shakespeare 1998]. The accuracy of these experiential simulations is based on distinct criteria to those of conceptual or more abstract simulations of physical data, such as graphs of illuminance levels [Meyer et al. 1986]. One critical but problematic condition is the portrayal of an architectural proposal placed in its full context [Sheppard 1987].

This inclusion of contextual information has been established as a necessary aspect of simulation methodology for several decades in the field of environmental psychology [Appleyard 1977]. Unfortunately, it is not reflected in current computer representations of architectural proposals, where the contextual information depicted in computer generated presentations appears profoundly inaccurate, overly simplistic or is even ignored entirely [Morgan 1995]. Experiential simulation operates at the limits of technical capabilities and is shaped by objectives and priorities of diverse fields, from cinema to medical science [Bosselmann & Craik 1987]. So it should not be surprising that issues specific to accurate representation of architecture should remain unresolved.

Many modes of representation in architecture appear to have qualities of realism, but are usually concerned with portraying some desirable design intentions or idealised view of the proposal. By contrast the computer simulation imagery dealt with here relates more closely to the plan and sectional drawings generated from the same source model. It endeavours to convey predictions about the attributes of a design that correlate with the eventual outcome. This means the ultimate objective is to portray the building just as it will be perceived; so rather than the simulation author, the design should *speak* for itself. The distinction is important since design intentions and eventual outcomes do not necessarily coincide.

The simulation system used to generate this imagery may be usefully structured into three parts:

- an input database describing project geometry and the environment that form the basis of the study;
- the model system that, via physically based algorithms, computes the behaviour of light and generates scenes as an array of luminance values;
- the media system that filters and projects the results as visual stimuli.

Visual context is defined as an enveloping ensemble of surfaces and light sources that form the stimuli for the surrounding *optic array* at an observation point [Gibson 1966]. It provides the visual cues for interpreting the environment: for instance relative depths and locations in a project may be perceptually inferred from the difference in size of familiar contextual elements, such as people or furniture [Ittelson 1951]. It is worthwhile to unpack this definition and review briefly the fundamental role of visual context as it applies in architecture, or more specifically during the design process, in the experience of architecture, and then in its representation.

It can be argued that architectural design deals with a creative synthesis of project objectives and requirements, combined with specific site and cultural conditions, to reach some optimal solution [von Meiss 1996]. Whatever convoluted path that general process follows, the contextual environment is the visual expression of many of these parameters and so is integral to the design process. To illustrate the sensitive nature of the design response to its surroundings, consider almost any building proposal that simply undergoes a change in its orientation on a site. In each case the building remains the same but the design itself may be radically transformed; from the circulation routes, the relationship of public and private space, to the effectiveness of solar access and control. Mere rotation of a building within its surrounding environment can produce entirely dysfunctional designs. Interestingly, the environment where this concept is not apparent is in the *empty and infinite* virtual realm of standard computer modelling packages.

Clearly this sensitivity to context is in contrast with the design of consumer objects that typically can be multifariously placed within various generic environments, like a toaster on a kitchen bench. In the realm of design such items form a staple of computer visualisation. The parameters and assumptions that underpin popular simulation packages for visualising such disconnected objects are derived from a wealth of psychological research regarding objects rather than environment perception [Benedikt 1979; Ittelson 1976]. It follows that such packages are not necessarily suitable for unqualified application in architecture.

The design process reflects the nature of the architectural experience itself where the material surfaces of the project are observed in the context of perceptual links to the environment [Hooper 1978]. This means that for evaluating depth or visual connection of a space containing a glazed window element, (which under differing light conditions can evoke a range of perceptions from translucent to opaque) consideration is required of not only the window geometry, but the consequences of light entering or leaving the space, the reflection in the glazing surface and the perception and physical interaction of the scene beyond and so on. These are not incidental details since changes to the lighting conditions or material attributes for the same design geometry can dramatically change perceptions. Simulation systems that do not account for such phenomena may grossly misrepresent the perceptual characteristics of the design.

Instead of the perception of singular buildings as objects, the experience of architecture set in its context may now be thought of in terms of immersion in and movement through a changing field of light borne information. The location and time dependent pattern of visibility that fills the optic array is known as an *isovist* [Benedikt 1979]. This concept should underpin the simulation of building proposals.

It should be recognised that except for very controlled circumstances like flight simulations, media systems simply do not have the capabilities to project a virtual environment that users are likely to find indistinguishable from direct experience [Wann & Mon-Williams 1996]. In general human visual perception is highly proficient at sensing the presence of a media system projecting the surrogate of reality. Viewing with binocular vision or movement finds a degree of parallax in a scene that reveals the relative distances of objects. With a typical simulation this serves to highlight the flatness of the display surface. Similarly with eye and head movement the contrast sensitive peripheral vision continually monitors the surrounding optic array, and so can quickly locate the frame or boundaries of the media system [Pirenne 1975]. Indeed where viewing takes place with reduced field and monocular vision, thereby removing the main cues for detecting media surface and boundaries, images are reported as being perceived with increased depth [Enright 1987].

So if the inadequacies of the media system clearly signals the simulation as representation and not direct experience, then increased reliance is placed upon the contextual information of the image to provide the means for the perceptual interpretation of the scene. This permits an engagement past the display surface to the image content itself. Without the familiar environmental context it is not possible to judge this content against prior experience of the physical world to ascertain the errors or apparent fidelity of the simulation.

In contrast with typical experimental conditions, the evaluators of architectural simulations are likely to be highly biased, since as clients, regulators or local inhabitants they have strong professional or personal interests in the the existing context and eventual outcome. The casual omission or symbolic representation of so-called peripheral elements in the environment, such as a local house or even a familiar tree, may understandably disturb their evaluation of the project itself [Decker, 1994]. As far as possible the input database should include the whole range of contextual information without presumption as to its relative insignificance. If the simulation portrays reduced complexity around the site then this should be precisely because that is what the design proposes to do. (Besides an overly complex or chaotic context might well form the basis for proposing a simple design solution.)

If these points justify the inclusion of context in computer simulation, then a range of inherent difficulties with standard modelling techniques need to be faced. Firstly as has been noted above, the unique form and configuration of contextual elements, such as landform, local flora and urban fabric, usually require individual construction and arrangement rather than relying on stock examples as might be done for office furniture.

Additionally elements found in nature are typically difficult to approximate by straightforward geometric means and so require disproportionate processing resources. Australian gum trees are not well represented by a few cylinders and cones, and one such tree can easily contain more facets than the entire building proposal. Indeed obtaining the myriad geometric or material data just for the existing *built environment* is normally extremely difficult.

A frequent quandary is determining the extent of physical limitations for the simulation system at both extents of scale; from dealing with distant landmarks and observation points, down to details of advertising signage and other street clutter. In the past these issues have pushed physical models to their practical limits of accommodation and miniature construction [Bosselman & Craik 1987]. Furthermore without internal miniature cameras these usually only provide viewpoints from some distant aerial position outside of everyday experience.

In many cases the best available solution has been a separate rendering of the project inserted into some existing photographic imagery, a variation on a technique known as photomontage. Unfortunately it is not always clear that the viewpoint and perspective parameters of both the photographed scene and project model actually match. Moreover the model image is inserted *manually* into the photographic scene with further retouching to account for scene changes, for instance where demolition of existing buildings reveals new parts of the context. The graphic process of photomontage does not provide a means to simulate the physical interaction between a project and its environment (and the related perceptual cues). So it is unsurprising that projects shown using montage images often have a detached or disengaged appearance from their surroundings. Manual retouching may conceal these inadequacies to a point, but such interventions detract immensely from the defensible validity of the visualisation [Decker, 1994]. As far as possible the simulation process needs to be transparent and assumptions clearly identified to the viewer.

Finally a structural problem exists with the funding of accurate perceptual simulation: there is an inevitable reluctance to finance computer modelling of context if it involves expensive and time-consuming efforts that are seen as diverting resources away from the project itself. Experiential simulation needs to fit as part of a broader simulation requirement, in the same way that conventional plans and sectional drawings are submitted to obtain regulatory approval.

METHODOLOGY

The previous section argued that contextual information must be included in any realistic simulation imagery since it is fundamental to the design, experience and evaluation of architecture. Given that perceptions are both individual and diverse, the representation must encompass a range of likely scenarios in attempting to give a more complete sense of the design. This implies simulation for numerous viewpoints and directions, as well as under various site conditions, such as season, time, or even weather. By contrast, computer animations typically provide a linear narrative of transient architectural imagery; a fleeting sequence along an unlikely, if not impossible, trajectory. The alternative methodology must deliver a practical and inexpensive means of simulation that can:

- provide a diverse range of viewpoints for the user, such as an array of positions across the site;
- give the user control of view direction, and hence image composition;
- allow the user to determine the rate of migration through the project;
- present the project under various conditions.

Ideally this should build on the results of related simulations (for example the lighting analysis) and be accessible for a group of individuals unencumbered by media paraphernalia.

Since the focus of the methodology concerns generating isovists, rather than just views of objects, it is worthwhile to structure the simulated environment into three distinct zones (fig. 1):

- the project core, which consists of any physical intervention on the site;
- global environment, defined by the existence of action upon or visual relationship with the project and user, including elements such as Sun, sky, skyline, and distant landform;
- local environment with the wider possibility of interaction with the project (casting of shadows, specular reflections, indirect lighting etc.).

Each zone corresponds to differing levels of simulation, or a different set of visual attributes. For instance the effects of parallax for different viewpoints are not necessary for distant elements on the skyline, but their crude outline information is required; they need only have shape rather than form.

It is apparent that modelling of the whole environment is utterly impractical so the strategy underlying this methodology will be to effectively reverse the emphasis between photograph and computer rendering in standard montage; that is to instead introduce photographic representations for the existing optic array within the computer simulation. These images will be used as colour maps selectively projected onto crude geometric representation of the environment, that will nevertheless preserve the isovist at that viewpoint. A simple example is given in the next section at a single viewpoint to illustrate the process clearly.

One technique to obtain the existing optic array for each viewpoint is to use at least two digital or photographic fisheye images to provide coverage of the entire optic array. Unlike hemispherical representation, the angular fisheye lens produces a flat image in which the altitude angle is proportional to the distance from the edge to the centre (fig. 2). This avoids the problem of reduced resolution for elements on the image horizon in a hemispherical projection, and behaves more closely to the notion of constant resolution regardless of the direction that final observations are made.

In practice this means capturing two images at a known location, orientation, and time, usually with one facing horizontally directly at the project (say in the direction of the y-axis), and the other by simply rotating the camera 180° about a point beneath the lens. A modification to the standard tripod attachment makes this a simple and fast operation, so that there is minimal time delay between images. Some care should be taken on cloudy days when daylight levels can change rapidly. In some scenes it is worthwhile to use various exposure times in both directions to ensure an optimum image for the whole optic array.

If the viewpoint is set at the origin orientated along the y axis then a direction in the optic array described by the unit vector (x, y, z), corresponds to coordinates (u,v) of the image:

$$u = \frac{x \operatorname{acos}(y)}{\pi r}, \qquad v = \frac{z \operatorname{acos}(y)}{\pi r}$$

where $y > 0$ and $r = (x^2 + z^2)^{1/2}$.

Similar mappings apply for $y < 0$ using the image representing the other hemisphere and for viewpoints other than at the origin. It is this transformation that is used to recover undistorted information in the optic array generated within the computer model.

The same images are then processed as opacity maps in order to separately identify the global environment, from the local environment, that is to designate points in the optic array that definitely belong to the global environment. Simple geometry is then generated for the local environment, which when combined with opacity maps can form outline shapes of the local environment.

Assuming a sunny day, then if the sun position is

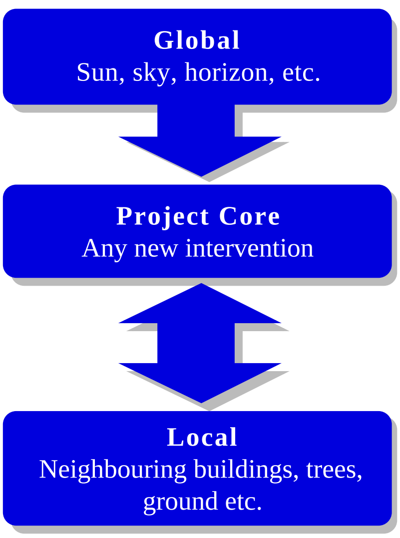

Fig. 1
Conceptual structure for the environment.

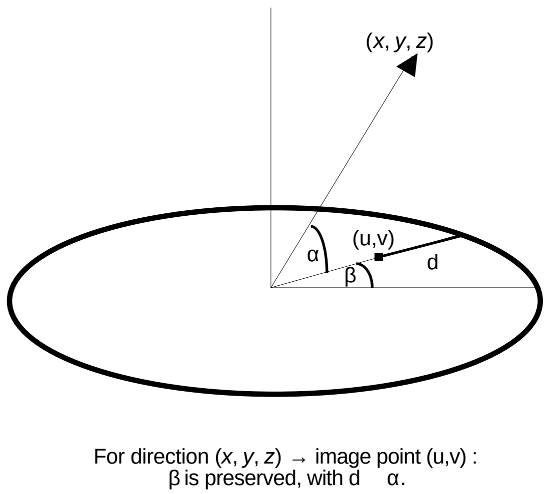

Fig. 2
Angular fisheye projection.

correctly set for location, orientation and time for the environment, accurate outline shapes in the right place will assure correct shadowing. Even for inaccurate geometry, shadows cast will be correct over the viewpoint from which the images were taken, but not necessarily for other parts of the site. Essentially errors do not matter for distant objects since they remain perceptually unchanged regardless of viewpoint. So while the mapping of the isovist provide detailed colour and outline shape information, errors across the site will depend on the distance of the object away from the viewpoint or from the project.

At this point the model of the project itself is placed within the local environment. Note that this process will automatically obscure parts of the existing optic array. This largely avoids any manual image manipulation or retouching required in removing existing buildings since they disappear behind the project model. However, a separate opacity map is required for any elements that lie visually between the observer and the project.

From this hybrid environment of existing image and project model, it is now possible to generate perspective views for any orientation required for each nearby viewpoint. Panoramic shots may be created for use with partly interactive media systems (such as QTVR) that permit the user to rotate the view as required therefore assisting with issues of orientation and navigation. For viewpoints further away from the origin so that errors are observable, the process of capturing the existing optic array at the new viewpoint needs to be repeated. While this simulation system is capable of generating the scene for whole optic array, current inadequacies in popular media systems still remain, such as limited screen sizes.

SIMULATION

The following example illustrates the process described in the precious section for a single viewpoint within a small site on the Sydney of University campus (fig. 3). The hypothetical project consists of the replacement of an existing cottage by a larger building containing seminar rooms. To informally judge the effectiveness of this example, a distinct design form is chosen to challenge the existing setting. Note that each of the following image types presented ought to be made available as part of the supporting information to assist with verifying the simulation.

Although a relatively simple project, with conventional techniques it would still require considerable effort to capture the existing fabric. The source images (taken with a Nikon E2 digital camera) are shown in figures 4 and 5, together with their respective opacity maps. The first faces towards the existing villa. The opacity maps are essentially representing the sky as global environment and everything else as potentially local environmental elements.

The two images are combined as an isovist and then mapped onto the basic model for the site using the opacity maps (fig. 6). The visual distortions that are obvious at this observation point distant from the origin, will not be apparent from views constructed at the origin point. The complex local environment has been approximated very simply by three vertical planes on a base consisting of two levels. The planes used for the outline shapes of the existing building are correctly located around the site corresponding to the building facades. Note that their complex outline is generated from the opacity map. The projection of the existing cottage is visible in figure 6 from this angle behind the new building. All the simulation imagery has been generated using the Radiance 3.0 Synthetic Imaging System but with the additional image mapping functions.

The correct sun position for Sydney at the time and orientation of the isovist is generated within Radiance, and is shown as matching that visible in the existing scene (fig. 7). The curved seam joining the two source images is faintly visible just left of centre.

So now it is possible to generate all the perspective or other view types required (figs. 7, 8 and 9). Since

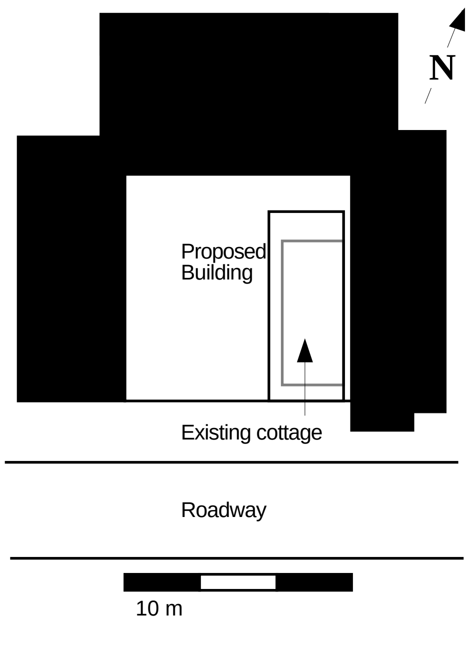

Fig. 3
Site plan for hypothetical proposal.

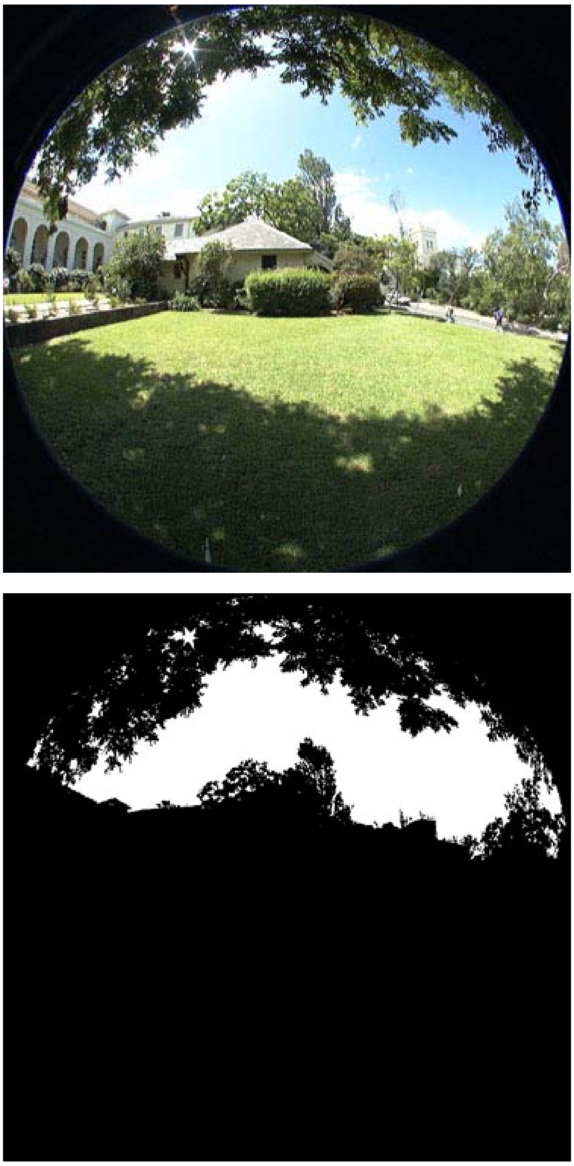

Fig. 4
Initial eastwards fisheye image with opacity map.

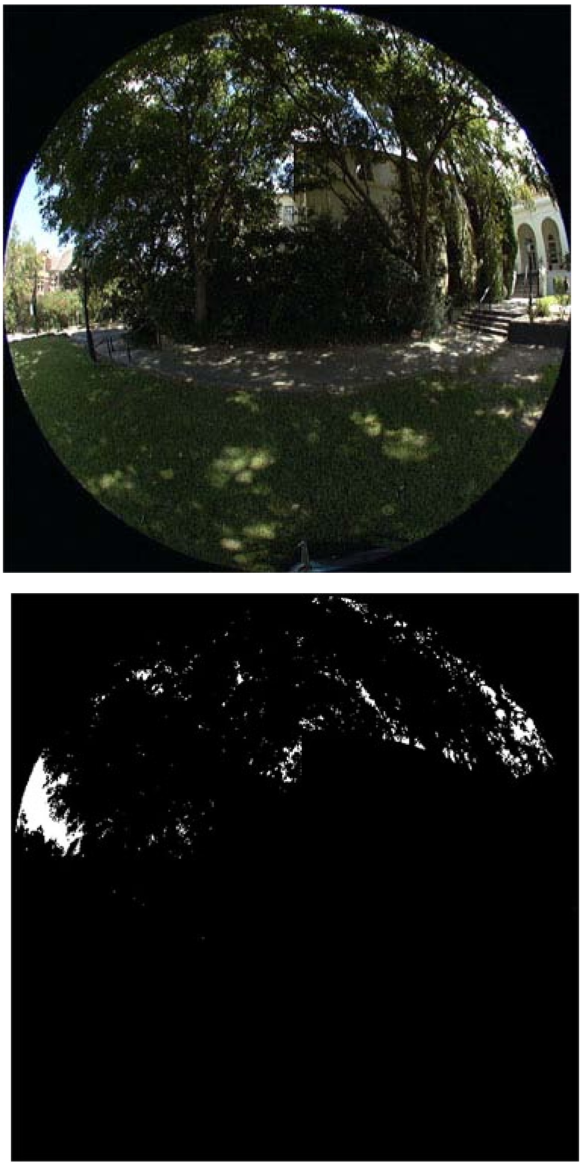

Fig. 5
Initial westwards fisheye image with opacity map.

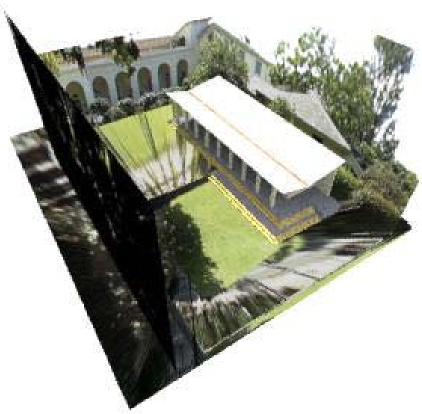

Fig. 6
Distant view of local environment, with surrounding building outlines, and project model.

the project is correctly placed on the site, the perspective from the original isovist matches the project building perspective automatically. The two height levels of the base are important aspects of the local geometry since they directly intersect with the building. Some errors are perceptible, like shadows near the new steps that are from bushes in the original isovist but have been removed in (actually concealed by) this proposal.

While the limitations of the media are a separate issue, simulations that produce panoramic views from the origin permit the use of display tools such as QTVR. These allow users to dynamically orientate themselves on the site without being forced to accept a previously chosen composed view of the project, and to progress though the site at their own pace.

Fig. 7
A generated angular fisheye view.

Fig. 8
Perspective from origin looking north.

CONCLUSIONS

This approach is concerned with the context that envelopes both user and project. By treating the simulation database as a series of visual environments at specific locations, rather than objects that need to be individually modelled, it has been possible to capture some aspects of the context in a highly efficient and practical way. Even the process of capturing imagery on site, with a known position, orientation and time, for each key viewpoint is a relatively simple operation.

The only manual intervention in the imagery is the selection of opacity maps and the construction of local geometry. Both steps are easily inspected for critical appraisal. Indeed the absence of retouching work, that normally forces a separation of the design and representation tasks, means that the project design may be actively refined within its contextual environment. Another related point is that here any perspective image required can be generated from the information in one isovist, again without the

Fig. 9
Another perspective view from origin

Fig 9. Panoramic view suitable for use with a QTVR presentation.

intrusion of the simulator.

The presentation of the simulation results for the whole project should provide the equivalent imagery shown here, with multiple viewpoints generated for each isovist obtained, typically arranged as an array across the site.

Research is presently underway to use the digital source imagery into luminance maps, which may be used as an integrated part of lighting analysis. They would be particularly advantageous if elements such as neighbouring buildings are acting as strong sources of indirect light. Validation studies to determine the visual attributes that can be evaluated accurately from experiential simulations of architecture, need to be performed generally. Although arguably better than many, the results of this approach are no exception and experimentation along these lines is already planned.

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