LOCAL VALUES in a NETWORKED DESIGN WORLD

ADDED VALUE OF COMPUTER AIDED ARCHITECTURAL DESIGN

DUP Science
Figures 1, 2, 3, 4.
Communication Playground01

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Brief description

The Communication Playground01-Project represents an experimental game structure, where new communication strategies in the Internet can be tested in a game situation. The realisation basis is provided by the first-person shooter game ‘Quake III’. The idea is to create personal, demanding virtual realities in which individuals can meet and communicate via the Internet. The implementation of Avatars enables the individual to receive visual feedback from the chat partner in real time. In order to create an appropriate environment to experiment, a game was developed to promote and also provoke these requirements purposefully. (figure 1)

Communication

The most important traditional means of communication in architectural representation include design perspectives, models, 2D profiles and plans. Increasing implementation of computers in architect offices has initiated a shift towards digital images. More and more sophisticated programmes are appearing on the market enabling the creation of more and more detailed, digital, three-dimensional models of an object. These can in turn be used to create pictures and animation sequences, which can be used to a greater or lesser extent for spatial representation and the transfer of ideas, depending on user ability, time invested, computer capacity and the type of program involved. In cinema and advertising these techniques are used to create virtually perfect realities, something which most architect’s offices do not automatically strive to achieve. Each office tries to retain a personal style, and the financial expenditure is too great for normal architectural projects.

The above-mentioned representation forms share a common disadvantage: the viewer is static and has no opportunity to act. This ought to be an important aspect especially in architecture and architecture courses where the viewer should be able to look at an object from all sides, to move through it, and to act freely. This step would open new parallels to physical constructions.

The automotive industry has been taking advantage of this type of virtual reality for quite some time. To reduce development periods, companies now draft and design complete vehicles, from the motor to the passenger compartment in their own virtual
realities. This enables early recognition and rectification of faults, particularly where complex objects are concerned. Especially where high component density is involved, overlapping frequently occurs and this means that modifications are costly. In the high-end sector there are numerous opportunities, e.g. the DaimlerChrysler Virtual-Reality-Center in Sindelfingen. Developers there have three interactive visualisation systems at their disposal: a 200° surround projection system for 2D representation is used above all for ergonomic investigations on the (real) passenger compartment and for driving simulations. The ‘Cave’, a five-sided back-projected cube with a 2.5 m edge-length, enables 3D assessment of the vehicle’s interior design at a very early stage. The computer determines the head position of the ‘driver’ via tracking shutter-glasses, which also provide a convincing 3D effect. Lastly, the ‘Powerwall’, also a back-projected screen, approx. 18 m long, is especially suited for design viewing and visualisation of numeric simulations such as virtual crash-tests. The large area with a resolution of 6000 x 2000 pixels allows for three-dimensional viewing by a greater number of viewers – the subtle effects of a special paint finish can also be viewed on the Powerwall.

This working technique can be easily transferred to architecture. Unfortunately, these virtual-reality-systems are extremely expensive. A number of research groups are however attempting to develop similar systems with conventional PCs and commercial beamers. When these research products have reached a certain point of development it would be interesting to implement the systems in architecture courses. The systems could be integrated into the architectural working process and participants could experiment with completely new design methods. Various spatial impressions could be experienced in real time and compared with each other already in the pre-drafting stage.

With greatly reduced technical requirements and expenditure, certain computer games can be converted to perform design and form-finding tasks. First-person shooter games are of interest for architectural representation. They generate a three-dimensional environment where the player can move freely in real time. In addition, it is possible to integrate such virtual worlds in a network, and this enables various users to act within them simultaneously, i.e. they are able to view a building, move inside it, and communicate with each other. Most games provide appropriate design tools with which more complex environments can be constructed. Thus interactive worlds can be simulated on the computer with limited effort and in a very short space of time and these are able to compete with complex simulations on large-scale computer systems.

**First-person shooter**

In September 1994 American Software development company ID presented the game ‘Doom’. It was the first game to be set in a three-dimensional, virtual world. The game’s principle was simple: the player had the task to pass through a level in the form of a labyrinth, shooting as many opponents as possible in the process. In ‘Doom’ the individual player’s field of vision was completely transformed, i.e. the levels were no longer viewed from above, as in the old two-dimensional games, but the player appeared to be the centre-point of the action: the game was experienced in the I-perspective, with the same limited field of vision the player would have in reality. The games ‘Quake I’ to ‘Quake III’ were developed in accordance with the same principle. The games acquired cult status, but their brutality caused them to be placed on the index of forbidden games.
The basic principle of the games remained unchanged in all the various versions. Over the years, skilful optimisation of geometries and textures enabled ID to achieve outstanding representation speeds on conventional computers. In addition, rapid advances were made in graphic-chip development and the complexity of PC-processors has now been matched. Nowadays, target groups are above all PC players and 3D virtual-reality-users. As the games market is constantly growing and will soon have reached the sales levels achieved by Hollywood film studios, software developers will develop ever-improving products, and will not rest until their synthetic sceneries possess photo-realistic quality. As all these developments were taking place, a huge fan community grew up and these fans produced various small auxiliary programs in their leisure time. In this way, complete level-editors were programmed which enabled the construction of individual worlds and allowed other players access to them. As there is great interest in such level-editors, a number of game producers are now giving away such design programs with the game itself. As a rule, the various fan-groups have their own websites offering all important up-to-date information and downloads. (figure 2)

**Level-editors**

The various level-editors usually work according to the same principle: they try to give the user direct, visual feedback concerning his/her work. Shareware programs in particular, strive to enable rapid intuitive design and construction. As a rule, there is not even an opportunity for numeric input of certain values. It is exactly this rough mode of working on the part of the editors which can support the architect in early drafting phases. At this point there is no need for numerically perfect CAD data. Professional visualisation tools work with a level of precision which would reduce efficiency in this phase. Another important aspect is that level-editors compensate for their imprecision through their immediate representation and thus can be used for a direct check of earlier spatial designs. This sketch-like, three-dimensional working method is particularly suited for concept work with space, and facilitates the form-finding process.

**Process**

The above-mentioned process employed by the level-editors is of particular assistance in the form-finding phases. The graphic-engine is responsible for the representation of the individual game. It transfers the data to be calculated to the computer’s graphic card. The various graphic cores of the games do not differ greatly as far as the basic construction is concerned. They are closely linked with graphic card developments and endeavour to utilise them in the most effective manner possible. The differences are to be found in the details, e.g. that there is a polygon limit which just enables fluid game progress. To save on polygons, objects further away are represented in less detail, i.e. with fewer polygons. The different software developers have their own procedures to generate images of the individual polygon objects with higher or lower geometric resolution levels. The advantage is obvious: the better the polygon reduction problem is resolved, the more objects can be represented on the screen.

An important aspect for architecture representation is the handling of textures and, especially, light. Let us analyse how an individual image is built up: First the graphic chip determines the surface relationships – it draws the objects supplied as a polygon net and fills the surfaces with textures. In a second step, it determines the visibility of each individual image point. With the aid of the values in the Z-buffer it regulates the depth
coordinates of all pixels and recognises which pixel is covered by one positioned in front of it. This appears simple, but is a highly complicated process. To generate a realistic representation, the graphic chips must first perform complex filter operations. If the textures were to be taken over unfiltered, they would appear as a chess-board on the screen and would flicker at a greater distance. Developers try to eliminated these undesired effects by means of interpolation methods using bilinear and anisotropic filters. Multi-texturing is particularly interesting for architecture representation. This process promotes the implementation of textures with multiple layers. Modern graphic chips possess complicated texture-combiners, which process further parameters with the aid of the various layers to calculate the final colour values. This method is most frequently implemented in the generation of any desired light distribution patterns. A light/dark pattern is used as a second texture, and is then covered by the actual texture. Bump-mapping is a further application involving multi-layer textures. It enables the simulation of surface structures which make the implemented component appear realistic and solid.

When the geometries have been checked in the first calculations, the illumination level of the different surfaces is determined. The concluding calculation does not only simulate direct light, but also includes the diffuse light proportion. The resulting light conditions are very close to reality and, in combination with the materials implemented, generate an atmospheric locality. To make the virtual-reality even more plastic, additional sound types may be added. For instance, materials can be combined with the appropriate sounds so that the noises created by a character’s movements are made more effective. Each room can be given its own sound backdrops which can then be heard as a whole sound picture, or individual sound sources are implemented which become louder or quieter, depending on the distance involved.

From the time ‘Doom’ appeared, first-person shooter games have been more or less network-capable. This feature means that games and virtual-reality are independent of locality and can be played with other players worldwide. At the beginning of game development, data transfer was slowed down by the speed of inferior modems, nowadays higher data transfer rates are possible. This has enabled new developments in the sector. In ‘Doom’ only the required position and game data were transferred, but since ‘Quake II’ players have been able to communicate live and in real time via the internet. This means that a player can communicate with other players and discuss points relevant to the game. A special headset is generally used as an interface, and this simultaneously condenses the sound data and relieves the computer. At the same time, the player’s hands are free and he/she can continue to take part in the game while speaking.

**Cost factor**

Finally, it is worth taking a look at the costs. Professional animation and 3D-rendering software costs at least €2500, although the average price would tend to be in the region of €5000. On the other hand, acquisition costs for game systems, around €50, are relatively low. The appropriate game editors are usually provided free-of-charge by the producers, or can be obtained for very little money as shareware on the Internet.
**Computer game fascination**

Several researchers have posed the question of how the fascination for computer games can be explained. An American study carried out by the industry association Interactive Digital Software Association (IDSA) indicates that the challenge of the game and stress relief are the two most important aspects from the user point of view. Pedagogue Jürgen Fritz, on the other hand, came to the conclusion in his research project that the crucial aspect for the user was the fascination of being a part of the action on the screen. The active influence of the user on what is happening gives him/her a feeling of control, power, domination and success. A further important aspect is that the player has the power to control different situations and can prove himself/herself when faced with difficulties. In addition, the patterns and levels of difficulty available are easily recognisable, and players can select their own level of difficulty as they wish. The so-called ‘flow-state’ (Mihaly Csikszentmihaly) cannot be achieved so easily in any other intensive play situation. In a computer game players become completely absorbed in the game action. (figure 3)

**Project phase**

All the above-mentioned aspects were to be integrated in the Project, which is based on the ‘Quake III’ graphic engine. At the beginning of the Project it was not yet clear how all these points could be combined. The objective was definitely not to programme a new level for the game. The aim was rather to try to experiment in the zone where architecture and exhibition design meet, mixed with new communication strategies. At the first meeting it became obvious that we did not wish to merely develop concept localities for subsequent presentation to the public. We wanted to integrate the viewer fully in the virtual installation. The viewer was to have the feeling that he/she was compelled to move through all the installation localities. The viewer was to be motivated to do so. This is most easily achieved by awakening the viewer’s play instinct and creating a certain suspense. The next point was to promote communication between the players during the progress of the game. As communication in a normal first-person shooter game is negligible, or confined to brief orders, we tried to transform the whole first-person shooter principle and create a new game. The game structure was then based on a new, greatly altered principle.

**Communication Playground01**

The Communication Playground01 Project represents an experimental game structure, where new communication strategies in the Internet can be tested in a game situation. The realisation basis is provided by the first-person shooter game ‘Quake III’. The idea is to create personal, demanding virtual realities in which individuals can meet and communicate via the Internet. In the Communication Playground01 Project the ‘rooms’ are not on the Internet, the individual has the virtual reality environment on his/her computer and only exchanges position and audio data with the contact partner via the Internet. This has the advantage, that the individual can use the full range of the Internet bandwidth for the compressed audio data and that the virtual-reality on the player’s own computer is not affected. This means that complex virtual locations can be created, which are only limited by the computer involved and the capacity of the graphic-chip. By the use of Avatars the individual gets visual feedback from the chat partner in real time.
Figures 5, 6, 7, 8.
In order to create an appropriate environment to experiment, a game was developed to promote and also provoke these requirements purposefully. (figure 4)

**The aim of the game**
The aim of the game is to gain experience in reference to the following questions:
- How to move in virtual spaces?
- How to handle the communication between the players?
- How to interact with virtual avatars of the player?
- What kind of architectural methods can be used?

**Basics**
For the architectural and technical realization of this experiment, Communication Playground01 uses the graphics core of the computer game Quake III. By the use of the modern graphics engine and the strongly compressed audio transmission over the Internet, Quake III can be used to establish virtual architectural communication areas. The project is based on the idea to create virtual areas with simple means and conventional computers and to use these for different experimental methods of communication. The essential characteristic of the project is to change the context of the original game in order to create a new communication platform for students. The means of interaction in the game’s environment were modified and partially renewed for this purpose. The destructive character of the original game was completely rejected, i.e. the weapons were switched off, the fantasy figures were replaced by more realistic figures and the sound environment was transformed. The central element of the new game is the communication between the players in a virtual building in a multi-user environment.

The experiment took place in three phases:
1. Definition of the game rules and development of a communication principle
2. Test phase: realisation of small-scale exemplary communication platforms
3. Starting period and realisation

**Structure of game**
The game is played with four players over a local network or globally over the Internet. The aim of the game is for all four players to reach the next level as fast as possible. It functions only if the participants recognize that they can cross the activity spaces only as a team. After the start, the team is separated spatially and visually. This means that the players can only communicate with each other over their head-sets. The actual game begins within these areas. Each player has a task that must be recognized in order to solve or to use it. From this step on, the players must recognize that their functions (tasks) are always directly connected with the obstacles confronting the other players. The logical construction of the map means that all problem solutions are coupled directly to the tasks of the players. Every player is forced to communicate via head-set with the others as only the first-person shooter perspective is available on his/her screen and the players are spatially separated from each other. The audio connections are designed in such a way that any player can speak directly to any other player and all the players can make a contribution. To reduce the amount of time required for a level, a good communication structure must be found and the players must develop an orientation.
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In the next section, starting intersections, the players begin to grasp the logic of the game, i.e., they must realize that they can only progress when one player opens the way for the other. At this intersection the group of four is split up into two pairs. In the next stage, the pairs are split up again, and transferred to the four rooms.

**Figures 9, 10, 11, 12.**
basis. This team cooperation will eventually enable the players to leave the activity locations and transfer to the next level. (figure 5) (figure 6) (figure 7)

**The game**

*Starting room (figure 8)*
The 4 players start the game here. Each player can only see his/her screen. Following a brief orientation phase, the players leave the starting room for the first intersection where they then split up.

*1st Intersection (figure 9)*
In the two starting intersections the players begin to glimpse the logic of the game, i.e. they must realize that they can only progress when one player opens the way for the others. At this intersection the group of four is split up into two pairs. In the next step the pairs are also split up and transferred to the four main rooms.

*Control room (figure 10)*
Person A is in a darkened room with a transparent floor. Through the floor the player can see the labyrinth from above. This player is in the communications centre; this is the collection point for all visual and acoustic information. Person A must try to guide B and C, who can be seen walking around below, through the labyrinth.

*Labyrinth (figure 11)*
Following teleportation, Person B is in the left section of the labyrinth. The player is able to look for an exit, but encounters locked doors which need to be opened. Both persons in the labyrinth give Person D in the switch-room commands concerning the doors to be opened. The left-hand labyrinth is spatially connected with the right-hand labyrinth. (figure 12)

Following teleportation Person C is in the right-hand section of the labyrinth. This player has the same possibilities as Person B in the left-hand section. In the entire Labyrinth there are several doors connected with teleporters which transfer the player to an unfamiliar place in the labyrinth. This creates a second, non-transparent labyrinth level, which makes orientation more difficult and compels the players to communicate more closely with the control room.

*Switching room (figure 13)*
Person D has been in the switching room since the players split up at the first intersection. In this room there are a number of switches and these are marked with symbols in the same way as the doors in the labyrinth. The switches control the corresponding doors in the labyrinth. The switches are counter-coupled, i.e. only one door can be open at any one time. This counter-coupling means that Person A in the control room must think of a strategy to help Players B/C to solve their tasks.

*2nd Intersection (figure 14)*
This last intersection functions as a lock. It ensures that individual players cannot leave the main rooms and prevents players reaching the next level alone, i.e. there is no way to
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Figures 13, 14, 15, 16.
reach the next level until all the players arrive at this intersection and have solved all their tasks.

*Conclusion room (figure 14)*

All 4 players are together again in the conclusion room. It represents the end of the first level. From here the players are transferred to the next level.

**Evaluation**

A number of other functions were also considered in the early phases of the Project, but these could not then be realised in the final test design. This was due to various reasons: an important factor was the enormous amount of time involved. At the beginning, a number of small-scale test levels were set up to have a better idea of the duration of the Project, but unforeseen problems kept arising and this interfered with the schedule. (figure 16) Several planned features could not be realised as a result:

For the final version we planned to replace the Quake Avatars with new figures. This was to break up the aggressive character of Quake and underline the new identity of Communication Playground01. It would have been better to analyse the users’ reaction to the Avatars. Unfortunately, the technical realisation turned out to be more difficult than we had assumed. The integration of Bones in the finished polygon figure repeatedly caused problems, so that the prototype could not be implemented in the final version.

In the early phase of the Project we considered the implementation of 3D scanners to scan the individual players on site and integrate them directly in the game. The idea behind this was that this very personal type of Avatar would make it easier for the actors to enter into the parallel world and would promote immediate contact between the players. It soon became clear that this idea was impracticable as it was impossible to find any mobile 3D scanners to rent. Instead, we resorted to working with face textures and prefabricated polygon models.

To make the interface computer/human more physical, we planned to implement motion tracking, possibly in combination with a virtual reality helmet. Some experience was gathered with motion tracking but it was unsuitable in combination with a screen. As another possibility we considered using relatively inexpensive virtual-reality helmets. These are equipped with 3D simulation, stereo sound and head-tracking, and they were developed for use with games such as ‘Quake III’. On examining the technical data it turned out that the horizontal angle of vision is 35° and a focus distance is specified as 3,35m. The picture can then be calculated to be approx. 2m wide and positioned at a distance of 3.4m away from the viewer. For a 17’ screen this would correspond to a distance of 0,5m. This is the equivalent of sitting in the back-row of the cinema instead of the desired integration in the virtual-reality. The fitted head-tracker would have been ideal for the Project. The tracking process worked with quite good precision and provided for realistic changes of perspective in accordance with the head movements. As the virtual reality helmet only provided a relatively unstable and rough pixel image, we chose the least expensive variant and used screens for the installation process and worked without trackers.
The people attending the presentation at Hochschule für Gestaltung Karlsruhe were very enthusiastic. Motivation to try the new game was generally very high. The idea of using the game structure as a basis was a success – people were eager to play and the motivation to discover the rooms was enormous. As expected, it took some time for the players to get accustomed to the new game situations. Most of them had experience of the original game and were expecting a lot of shooting action. When they realised that this was a group game and one which could only be solved by good communication, the concept was rapidly accepted and there was great competition to get the best score.

(figure 17)

When considering the objective of the Project, it can be stated that most of the players had no major problems to do with orientation in the rooms. This was due to the fact that the players were mainly students with experience with computers and games. Not a great deal can be said following this test concerning reactions to Avatars and their facial expressions. The problem lies in the construction of the map. Separation of the players at the beginning of the game forces them to communicate with each other through the whole level, but they seldom actually meet. To investigate these reactions more closely, a new game structure would have to be developed for the next level.

The answer to the question of the architectonic tools is not so easy to find. The first problems in designing for virtual space are encountered right at the beginning. In reality we often curse gravity and the problems it causes, but at least it provides a certain basis.
More or less anything is possible when virtual worlds are designed, but this does not always make things easier. There are also new aspects to be taken into account. For instance, the game is designed for fast movements and this often appears hectic and nervous. It is almost impossible for a player to register the whole level, and a fragmented connection of the image sequences is created in the mind. Depending on the sphere of application, this characteristic should be counteracted or at least not encouraged. In a normal architecture presentation, for instance, the use of teleporters would be dispensed with. This function transfers a player from point A to B without any visible path. Flickering images or constantly changing textures are another aspect. They interfere with the perception of inexperienced users and make them tire faster.

The programs must not be used merely as pure visualisation tools; they have a much greater potential. Localities can be designed which change with time, e.g. through manipulation of form or room sequences. This can confuse the visitor additionally or lead the player straight to a certain point. It would be interesting to develop a new level with the experience gained and perhaps integrate one or more of the functions not as yet realised.

**Perspectives**

In my opinion, the next step should be to leave the experimental phase and begin to develop a multi-user communication platform for students of architecture. One idea would be to meet other people in architectonic rooms via the Internet and use these as a kind of chat-room. I believe it will become increasingly easy to create a personal Avatar with the user’s own characteristics and possibly coupled directly with the user by means of personal face tracking. This would mean the creation of an unmistakable individual personality for the virtual reality. If such a development is linked to the implementation of architectonic rooms, completely new possibilities are created for communication via a network. With the aid of this type of environment and the Avatars, the immediacy of the system would be emphasised and personal contact would be intensified. Environments would be possible which are the actual design. Users would meet in the virtual building and examine and assess everything together. (figure 18)

The dream is the development towards simpler and less inexpensive systems. It would be possible even today to exploit the potential of various game consoles to create virtual-reality. They are already available in many households, or can be purchased at very low cost compared with the costs involved for high-performance computer systems. Their system architecture is optimised for the representation of 3D worlds and they are able to log into servers on the Internet, two features which offer excellent possibilities. A further advantage of consoles would be that the enormous competitive pressures between various producers means that developments will be pushed forward continuously. In combination with an export tool for a standard 3D modelling program, a new marketable variant of the experimental Communication Playground01-Projekts would be created.
References


Bertuch Manfred. “Polygonfabriken” CT-Magazin. 08 (2001)


Synworld. <http://synworld.t0.or.at/console.htm>, [19.02.2003]