A NEW CONCEPT IN CERAMIC SPECIFICATION USING VIRTUAL ENVIRONMENTS

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ABSTRACT

An old problem in ceramic prescription has been and still is the physical impossibility of presenting all the ceramic product ranges in realistic environments in tile showrooms.

The use of computers and especially computer graphics in real time have solved this problem by designing a tool that allows "strolling" through a virtual environment (bathroom, living room or kitchen), in which it is possible to show any ceramic element and immediately replace it by another of the same type.

The tool has been developed by the Instituto de Robótica of the University of Valencia in co-operation with TAULELL, S.A., with financial support by IMPIVA. The new tool has been called CEV, the acronym for "Cerámica en Entornos Virtuales" (Ceramics in Virtual Environments).

This low cost virtual reality system consists of a PC with specific graphics hardware for generating images, a multifrequency stereoscopic screen and a stereoscopic system for immersing the user in the virtual reality scene. Finally the mouse is the input device used to capture the actions of the user on his virtual trip. The software is in charge of maximising and synchronising the hardware capabilities via a user-friendly interface.

As an added value, the system is fitted with a module for calculating estimates based on the selected tiles and actual measurements of the environment to be tiled.

1. INTRODUCTION

Recent years have seen a tremendous boom in computer techniques relating to the world of computer graphics. Examples of these techniques are the 3D interactive graphics and especially virtual reality.

The world of 3D interactive graphics (also known as 3D graphics in real time) consists of a set of applications, systems and technologies directed at synthesising fictitious three-dimensional environments, which can be perceived by the user as if real environments were involved. The illusion of reality can be created to a greater or lesser degree depending on the specific needs of each case, from a PC video game to complicated flight simulators that need special input–output systems and computers.

Virtual reality is often related to the use of systems such as the virtual reality helmet, datagloves, stereoscopic glasses and other artefacts belonging to this world. These elements serve to enhance the illusion of reality but are not indispensable when it comes to implementing an application of this type.

1.1. VIRTUAL REALITY APPLICATIONS

Virtual reality was born at the end of the sixties, when the American Department of Defence was interested in technology relating to flight simulation. During its initial stage (seventies), the uses were just military and academic. The first commercial applications appeared in the eighties and at present the virtual reality market is rapidly expanding, marked by the appearance of a multitude of commercial products aimed at the PC world, promising fast growth in the short term.

There are many current fields of virtual reality applications: prototyping, simulation and instruction of specialists, handling abstract data, telepresence, and leisure. Virtual reality is used in flight simulators, instructing drivers of heavy machinery, operator training in complex systems (nuclear facilities), planning surgical operations, manipulating pharmaceutical molecules, geographic information systems, vehicle and ergonomics assessment, human factor and reaction evaluation, visualisation of architectural scenarios, theatre staging, etc. To give a few practical examples, the Japanese company Matushita has been using virtual reality for five years in interactive kitchen design for prospective buyers, allowing furniture locations to be changed and visualising the final appearance. The Caterpillar company that builds vehicles for construction and public works uses an application that allows verifying visibility in the company's new models, which has allowed reducing design time by 9 months.

2. VIRTUAL REALITY IN THE CERAMIC SECTOR.

The explosive evolution in interactive visualisation techniques of recent years has led to applications of these techniques extending to ever more industrial branches and social sectors. In this sense the ceramic sector can become one of the first to benefit from these technologies since the specific needs of the branch make it an interesting technique.

The first approach to creating the CEV concept was using a virtual reality system, which displayed on screen a realistically tiled room (bathroom, kitchen or lounge), through which to take a virtual "stroll", changing the tiling in the scene at any time.

The sought after objective was developing a tool that would permit generating sufficiently realistic images to enable the client to make an aesthetic evaluation. To achieve such realism, realistic lighting techniques were used (radiosity), as well as a stereoscopic system for achieving the necessary immersion effect associated with any effective virtual reality tool.

Virtual reality helmets provide inadequate resolution, so that they are unsuitable for this type of application. The output system is a high-resolution screen that can be combined with the use of stereoscopic glasses, yielding an in-depth vision of the scene, thus heightening the impression of reality. The use of stereoscopic glasses makes it possible for various people to visualise the scene at the same time.

The basic element of a ceramic application is the tile, which is set on the three-dimensional model as a texture. The systems to be used in a visualising application or manipulation of ceramic environments need to be able to work with textures in an efficient manner. This requires using special hardware, to date only available in very expensive computers. At present PC cards are being developed, which allow putting on textures in real time without excessive expense.

The hardware used for 3D graphics in real time is capable of approximately calculating scene lighting. Objects are illuminated taking into account their spatial orientation. Thus, a good spatial description could be obtained of the scene, though the quality needed to be improved. This was done by using more complicated lighting, which takes into account the physical characteristics of light propagation. Using this software method known as "radiosity", very good quality images can be obtained.

2.1. VIRTUAL REALITY APPLICATIONS IN THE CERAMIC SALES PROCESS

The ideal situation at a sales outlet is having a sufficiently large showroom layout to enable showing all the available collections. As this is impossible, small displays are typically used, recreating a small part of the whole collection, plus a series of photograph catalogues to cover all the available product ranges. A drawback to such systems is the fact that the environment created in the showroom or the catalogue will often not coincide with the spatial layout and measurements of the prospective client's environment. This makes the user hesitate with regard to the most suitable selection for the actual context to be decorated.

These problems can be solved by using 3D interactive visualisation techniques, which yield excellent results. On the one hand we can store all the ceramic models we like in a computer and present them in the same scene or different scenes. In a brief space of time, a bathroom or kitchen can be modelled for the client and various combinations displayed on the model. In this way the client no longer needs to imagine what the combination will look like at home, since he can take a "stroll" and see it directly. There are further advantages, since after having modelled the scene for visualisation, the number of tiles required for the tiling can be calculated, and an accurate estimate made based on the price of the selected tiles

3. CEV: A NEW CONCEPT

CEV (Ceramics in Virtual Environments) is a new Hardware/Software generation, designed to present complete tile collections in a realistic virtual environment. The system aims to provide the seller and the client with a reliable idea of the products displayed, and help in the customer's decision-taking process. The CEV tool has been formally designed to avoid the above problems and simultaneously allow:

- Creation of virtual environments with a view to displaying different tile compositions. The user "strolls" through the virtual scene with a high degree of immersion and good tile visualisation quality, including stereoscopic vision. The system is controlled by a graphics interface that sets up a simple interaction with the system.

- The immediate replacement of wall and floor tiling by others forms a database. With the aid of this system, the client or the designer can take decisions more easily than by consulting catalogues and do so with a greater degree of reliability.

- The CEV is installed on low cost computer platforms. A CEV can be quite accessible thanks to being based on PC type platforms with a special graphics card.

- The client can also handle a simplified model of his own room, with the real measurements. This model together with the selected tiles automatically produces an estimate that can be printed out.

3.1. CEV ELEMENTS

3.1.1. DESCRIPTION OF THE HARDWARE ARCHITECTURE

The production of 3D images in real time requires great hardware power in the computers that are to handle this type of system. The generation of a three-dimensional feeling is based on the images perceived by both eyes being slightly different as a result of interocular separation. To produce this effect a stereoscopic pair is generated in which each image of the pair corresponds to the projection that each eye should observe. By using a screen and a pair of special glasses, it becomes possible for either eye to just see the image it should. The fact of having to produce two images and synchronise the functioning of the screen and glasses requires fitting the computer with special hardware, mainly based on graphics accelerating cards.

The equipment is made up of the following functional design elements:

- System base computer: The base computer manages all the processes and runs the design and visualisation modules, as well as controlling the access to the tile model database. This computer inputs the data to the graphics accelerating cards so that they can yield the end images.

- Graphics accelerating cards: These run the graphics computations and allow several images to be generated per second. These types of cards have their own data storage memory and have several processors in parallel architecture. They make it possible too stick on textures in real time and work with 24 colour bits.

- Multifrequency stereoscopic screen: This involves a special screen that can work at twice the normal scanning frequency (120 Hz), on which the two images can be seen (alternative scans) needed for the stereoscopic effect.

- Stereoscopic synchronism system and glasses: The synchronism system manages the synchronisation of the multifrequency screen scans, blocking out the stereoscopic glasses so that either eye only sees the image it should.

The following can also be optionally added:

CD-ROM reader: As a store of ceramic tile catalogues.

High quality colour printer: To provide a hard copy of the created environments. These types of printers are capable of representing up to 16 million colours and are suitable for producing realistic images.

The following schematic sets out the system's functional design:

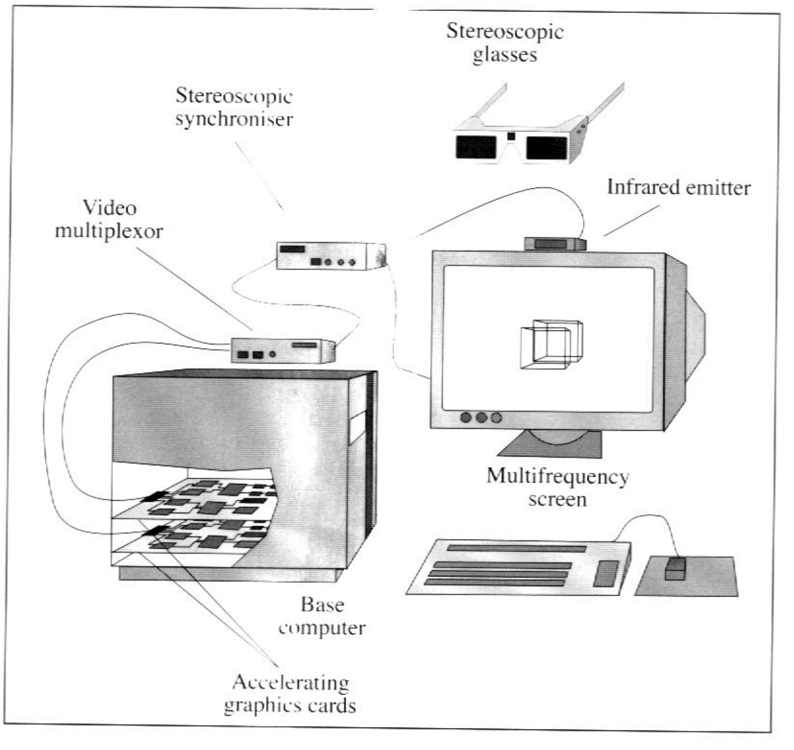

Figure 1. CEV hardware architecture.

3.1.2. SOFTWARE MODULES

A CEV must basically answer the need to visualise a given environment for a client, tiled with different wall and floor tile models, with the greatest possible realism. It also needs to produce a price estimate for the tiling with each respective design.

To satisfy these needs there is a:

3D Graphics library: This consists of a series of base graphics primitives and functions, programmed in C and C++, which are used as a support for modelling and visualising module programming.

Environment visualisation software: This is programmed on the 3D graphics library base. The software runs the visualisation and interactive stroll (in real time) through the environments designed with the environment-modelling module. It needs to exhibit a graphic interface that enables changing the various elements making up the environment (flooring, skirting, listel or trim).

This module, moreover, also manages the stereoscopic pair required to produce the sensation of depth in real time. It also allows working in normal use.

The organisation of the objects in this module is hierarchical so that their representation process is optimised, achieving the refresher frequency needed to run in real time.

Environment modelling system: This is the software that permits designing the various environments. It needs to be a simple module to handle, in which the non-specialist computer user can design a bathroom or kitchen in a matter of minutes.

The module is parametrically conceived, so that on inputting certain measurements, the design is automatically remade and adjusted to the measurements of any user's scenario.

The system needs to be fitted with a three-dimensional interface that easily allows situating the various items making up the scenario (sanitary ware, bath, closets, etc.).

It is moreover advisable for this software to have a CAD file input through the DXF format or other standard CAD formats, to allow introducing designs of sanitary ware, cupboards, etc. that are marketed by producers with commercial CAD systems.

Lighting software: This software is connected to the design module and determines the lighting, once the scene has been set and the lights have been positioned with the desired power.

The lighting model chosen is lighting by radiosity. In this model, lighting is determined on the basis of a physical model of energy transmission by light sources, and light absorption and subsequent emission by the objects making up the scene. A diffuse lighting model is involved, particularly suited to architectural applications.

Tile calculation software: This software captures dynamic data (produced by each designed bathroom), as well as static data (from the database), and calculates the total number of tiles needed. Based on tile price, the total cost of the selected tiling is then computed.

This software separation is transparent to the user, who sees the system as a whole without concerning himself with which part runs the function that the user calls up at each moment.

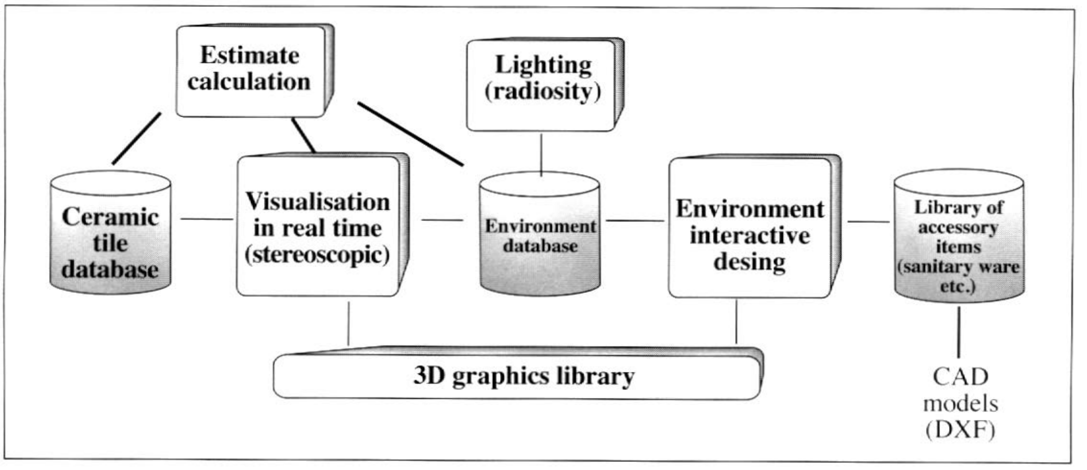

Figure 2. CEV software architecture.

4. THE TAU SYSTEM, FIRST EXAMPLE OF A CEV SYSTEM

The first CEV was developed three years ago and was set up as an R+D project between the University of Valencia and TAUGRES, one of the top companies in the Spanish ceramic industry, with financial support by IMPIVA.

4.1. TAU SYSTEM MODULES

The TAU system is made up of two modules, each of which forms an independent module by itself, though they are perfectly matched. The first of these modules is closely related to visualisation. This is the part that helps the client decide whether to choose one collection of ceramic products or another. The other module focuses on instantly computing the number of tiles involved and their cost.

4.1.1. REALISTIC VISUALISATION MODULE

The realistic visualisation module is closely related to the virtual reality techniques employed, as mentioned above, to provide a realistic feel and faithfully perceive the effect of different ceramic designs on environments that are similar or identical to those that the client wishes to tile.

The visualisation module consists of seven displays. Except in the first one, which is the presentation, and the sixth, which corresponds to the virtual stroll, in the remainder the user is asked to make selections. The user can go back from any intermediate display to the foregoing one in order to modify a selection made, or go on to the next display with a view to proceeding with the selection process.

Each of these displays is described below.

The first display is the presentation. Here we can decide to leave the programme or start it. Until a decision is taken, multimedia background music is played.

The second display invites us to select a type of environment as Figure 3 shows. The selection is made by clicking on the name or image of the environment involved. The lower part of the displays contains two keys, one labelled "Escape" and the other "Return"; clicking on either will return us to the first display; both have been kept in order to be consistent with the rest of the application.

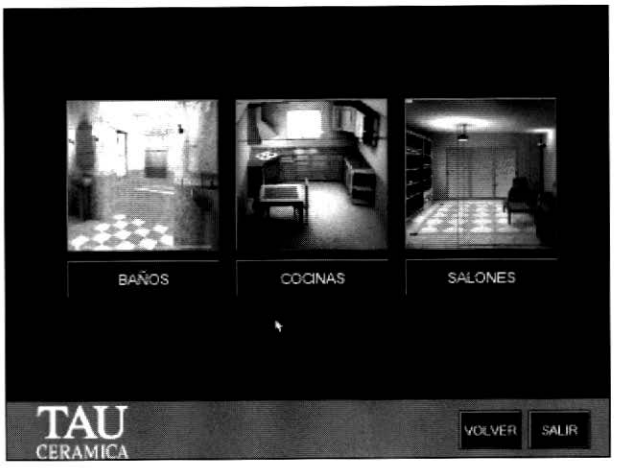

Figure 3. Display for selecting the type of environment.

In the third display, in the environment chosen in the foregoing display, the selection is requested of the tile size to be used in tiling the scene. Under each possible selection, there is a presentation containing information concerning the tile models appearing in the environment, as shown in Figure 4. A sliding bar under the models allows us to move through all the possible selections. As in the foregoing display, there are two keys, one labelled "Escape" and the other "Return"; clicking on "Escape" will return us to the first display; whereas "Return" takes us back to the previous display.

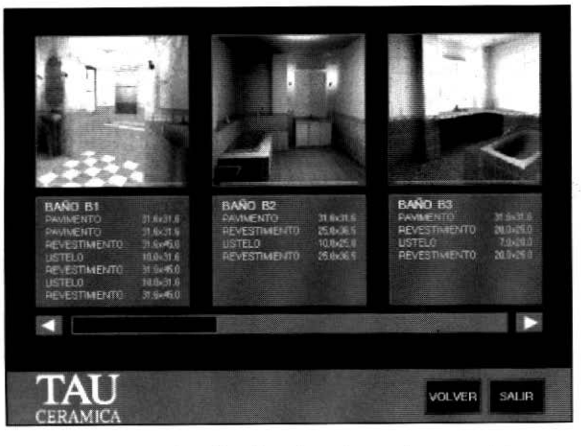

Figure 4. Display for choosing the environment form.

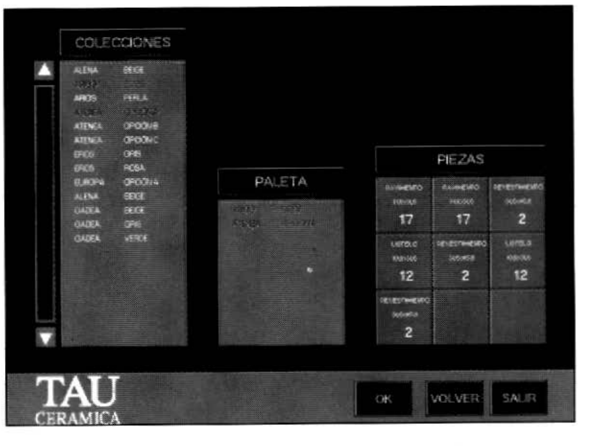

Figure 5. Display for constructing the collection palette.

Clicking on one of the keys leads to the next display, the selection of product collections. In this display there is an inset labelled "Collections", which presents all the available collections in the chosen tile size. A collection is chosen simply by clicking on the collection; the selection is undone by clicking on it again. All the chosen collections appear in the inset labelled "Palette".

To the right of the window there is an information box for each type of tile contained in the scene, that is, if for example the chosen scene appears as a chequered floor, two information boxes appear, referring to each tile making up the chequered pattern. Each data box contains three lines; the first refers to the type of tile, the second to the size, and the third indicates the total number of tiles that would be involved on adding together the corresponding models from each collection. As in all the displays, there are three keys: "OK" leads to the next display, "Return" goes back to the previous one, and "Escape" takes the user back to the original presentation display. Figure 5 depicts a selection example.

After clicking on "OK", we proceed to the tile selection display. This shows an inset for each selected tile in the scene. The information that appears is the type of tile, name, code, and picture of the tile. On the right there is a box containing a tree with unfolding branches. Each main branch contains the name of a collection, the sub-branches that dangle from the collection each contains a type of tile, and from these in turn spring as shoots each of the tiles of a concrete type belonging to the main branch.

The tiles are chosen as follows: each information panel can be selected. The selected panel is identified by its background colour, which differs from the others. Whenever a type of tile is selected, all the branches of the tree of the selected type unfold, to facilitate changes. Once the tile to be changed has been chosen, another tile then needs to be selected to replace it from the tree. On doing so, the information in the corresponding inset is updated, amongst other things showing the new tile model.

In this way we can choose all the tiles of a specific design; once the design selection has been performed, it can simply be stored by clicking on one of the keys labelled numbered 1 to 6, which appear at the bottom of the display. In this way it is possible to store up to six of these designs, although it is not necessary to use them all. Figure 6 presents the tile selection display.

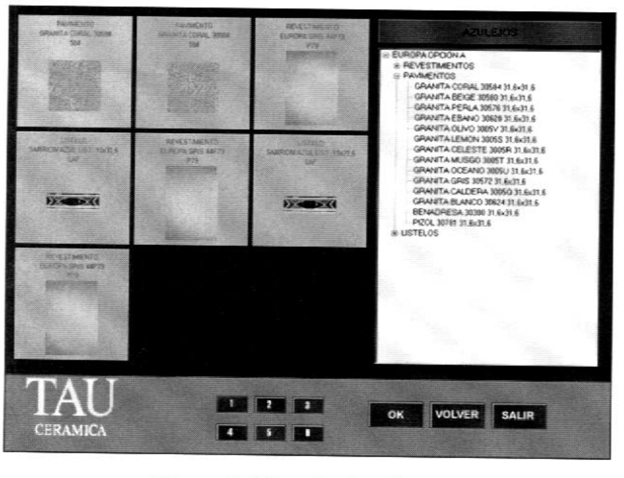

Figure 6. Tile selection display.

Once again we proceed to the next display clicking on "OK". The keys "Return" and "Escape" are also on view.

After selecting the tiles comes the flight display; in this screen the selected environment, decorated with the chosen tiles is presented in a realistic model. Using the mouse we can "fly" through the scene. The direction to be taken is chosen with the mouse cursor. Thus, if the mouse is moved to the right we need to move our head to the right, and the environment will rotate towards the left. The opposite occurs when we wish to turn towards the left. We can similarly lower our eyes to the floor or raise them to look at the top trim. To get closer or further away from the scene involves repeatedly pressing the mouse keys: the left key brings us closer while the right one distances us from a given spot. The system's main use and potential is tapped on pressing the 'O' key. This takes us into the stereo mode, i.e., using the stereoscopic glasses and the glass-screen synchronism system, we can "fly" through the scene while viewing it in three dimensions. The spectacular performance of the system is best demonstrated by trying it. Figure 7 illustrates a moment of flight without stereo. The other key functions are presented in the display and can be summed up as follows: 'A' takes us to the starting display, '*' takes the flight to the initial position, 'SAVE' stores the present combination to input it into the estimate module, 'ESTIMATE' presents the display showing the set of combinations presently chosen, as shown in Figure 8.

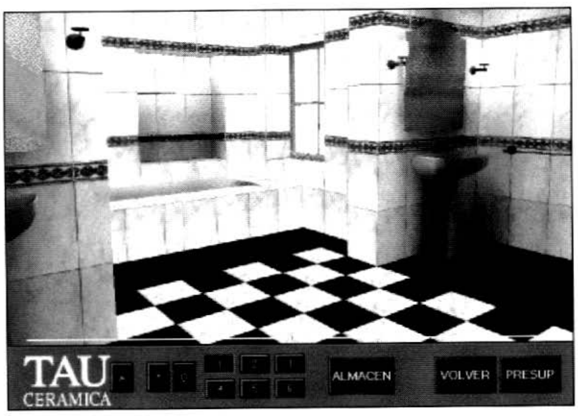

Figure 7: Visualisation and interactive flight display.

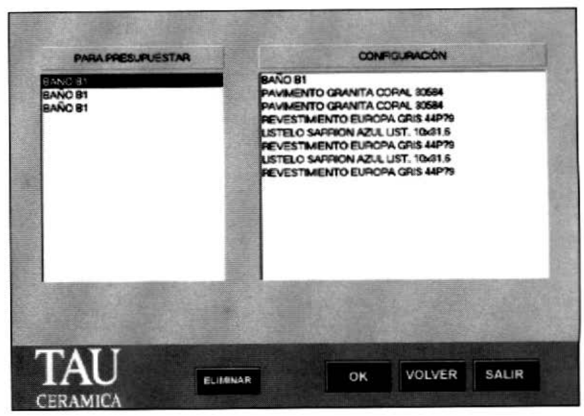

Figure 8: Selected combinations.

Any of the chosen combinations can be deleted from the selected combinations display before going on definitively to the estimate module, just by clicking on "Delete".

The visualisation module is the module that maximises the exploitation of the virtual reality potential. This is the module that solves the main problem, that of space, for the sellers, and on which the prospective purchaser will take his final decision regarding whether to buy one tile design or another. The following part helps fine tune the selection process amongst the pre-selected items, so as to obtain the one that best fits the particular geometry and distribution of the elements in the environment to be decorated, drawing up an accurate estimate based on the definitive choices made.

4.1.2. ESTIMATE MODULE

The main purpose of the estimate module is automatically calculating the number of tiles (in square metres if tiled surface areas are involved, in number of items if trims are involved), needed to carry out the tiling of the environment that has been designed and its cost.

On entering the estimate module, the first item that appears is the tool bar. The tile tool bar is set on the right side. Each element on the tool bar has an icon representing the element that is activated by clicking on it. The icons are shown that correspond to floor tile, skirting, listels, etc. At the bottom of the display lies the tool bar corresponding to the visualisation mode: N (New Design), P (Ground Plan), A (Elevation), 3D (a 3D vision is presented); clicking on one of these allows quickly going from one visualisation mode to another.

The steps involved in preparing an estimate are as follows: if we have come from the visualisation module all the pre-selections will have been made. To start the design requires selecting one of these pre-selections. This will cause the corresponding tiles to be loaded like the ones in the scene. After the selection, a tool bar will be loaded at the top of the display, with the furniture models corresponding to the type of selected environment; table, chair, etc., for a living room, washbasin and sanitary ware etc., for a bathroom, extractor hood and sink etc., for a kitchen.

The real design starts at the moment of creating the base outline of our environment with the mouse. To help in the design, the system has various options such as adding walls, moving or removing them etc. Having created the base and adjusted the dimensions, the objects are located in the scene, by selecting the wall that is to be associated with the object at point, and clicking on the object icon on the tool bar. These objects can be moved all along the wall to which they belong, both in the ground plan and in the elevation. Their dimensions can also be appropriately modified to match the actual size, for example in the client's bathroom. Figure 9 depicts an example of a ground plan layout, while Figure 10 illustrates an elevation.

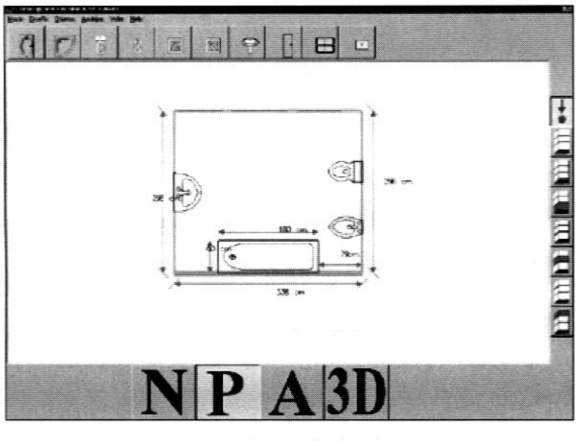

Figure 9. *Ground plan layout.*

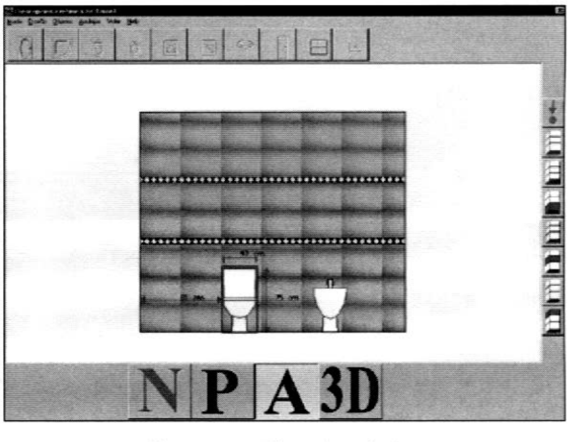

Figure: 10. Elevation design

After designing the ground plan and positioning the objects, the next step is to have a 3D look, and this is done by simply clicking on the key labelled 3D. Figure 11 shows a sample 3D view. In the 3D mode, the choice of viewing point is made by using the mouse. If the left key on the mouse is held, and we move vertically upwards, we approach the scene. If the direction is downwards, we distance ourselves from the scene. If the right key on the mouse is held, and we move horizontally, rotation around the X-axis occurs, while if we move vertically there is rotation around the Z-axis. A printed hard copy can be obtained from any viewing point by selecting the item "print" from the menu "Mode".

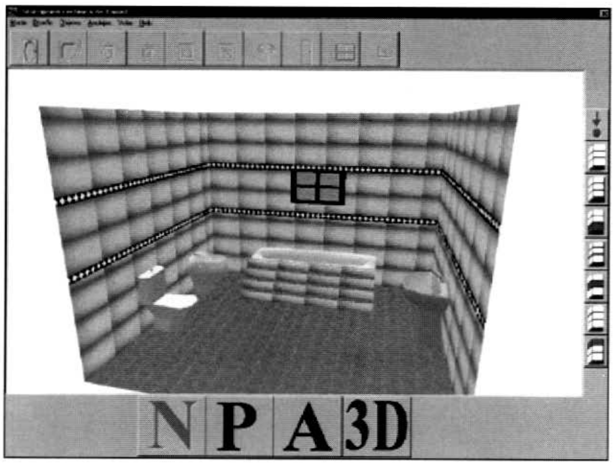

Figure 11. 3D view of a bathroom scene.

Any tile can be changed just by clicking on the key that represents it on the tool bar. If one of these elements is clicked on, a window opens showing all the tiles corresponding to the chosen tile model. One is then selected from the list and the 'OK' is clicked on. If a tile is to be eliminated, the window corresponding to the model opens and the key labelled "Delete" is to be clicked on.

If the client is satisfied with the decorated environment, the next step is visualising details setting out the price of each element, its weighting in the final price, and the end price itself. If the price is beyond the client's means, any element can be suppressed or replaced. Figure 12 presents such a list of statistics. When the seller manages to adjust the sales price, the end estimate can be visualised and printed out as with the 3D view. Figure 13 presents a final estimate.

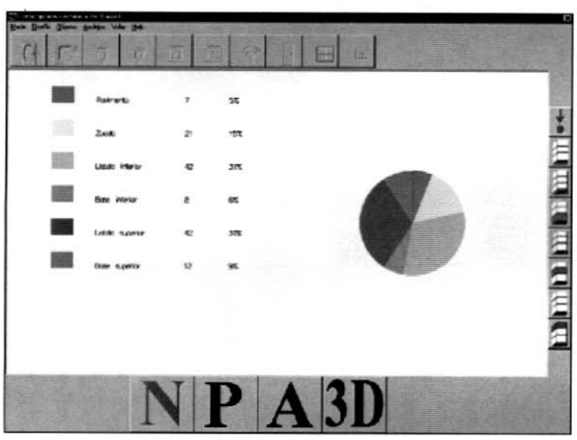

Figure 12. View of the statistics display.

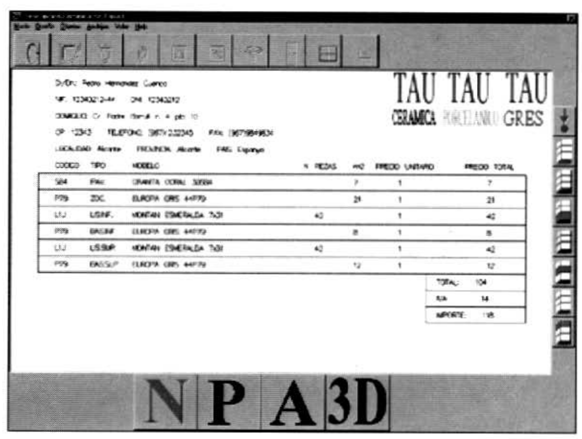

Figure 13. View of the final estimate.

5. FUTURE WORK

CEV is a wide concept but can be enriched with other ideas. It can for instance be extended beyond the original branch for which it was designed (ceramic branch) to sectors such as that of kitchen builders, furniture or textile industry. Its possibilities can also be enhanced by adding technologies associated with other scientific disciplines such as computers, telematics or multimedia.

The following improvements to the TAU system are planned: Opening a database so that models from other manufacturers besides TAUGRES can be incorporated. -Introducing a new tele-database via the Internet or information highway. -Extending the range of users to sellers of kitchens, furniture and textile products. There are still others that may look far off but which in time, as technology advances, will become attainable, such as creating a virtual sales system with portable computers, or telepurchasing from the home through the Internet, etc.

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