PRODUCTION AND TEACHING BY VIRTUAL ENVIRONMENT

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Abstract

We describe an integrated system, conceived according to the requesting given by teaching the production of Electronic Systems, more precisely Printed Circuit Boards (PCB), at the teaching institutions and training centres level. After a study of real necessities both in this type of institution as well as in industry and by using Virtual Reality and Multimedia techniques, we built a tutorial system, which leads the student through the faces of production of those components. The student interacts with the abstractions supported by three-dimensional (3D) manipulation and by visualising graphic scenes, visual vehicle used in transmitting knowledge. We also added textual information, sound and animation of those entities, resulting in a set of modules which will lead the user to an easy assimilation of the subject and an improvement manufacturing techniques, due to consequent subtraction of abnormalities in the production process.

Key words: virtual reality, teaching, manufacturing, multimedia, geometry, CIM system.

1. Introduction

By resorting to a Virtual Reality environment based by Multimedia technologies, we created an application of Computer Aided Teaching, starting with the capacity of representing 3D objects. The application simulates the faces of Printed Circuit Boards manufacturing process. This process, due to its complexity, usually leads to much waste and low readability, giving great importance to the formative aspects providing a learning of every phase of the process in as easier, tutorial, interactive, efficient way and where each student feels attracted to learning from this manufacturing method.

1.1 Virtual Reality

Virtual reality is characterized by the illusion of observing and participating in a synthetic environment of 3D objects [1] or a technology which associated to media elements (sound, image, movement, text) lets a user feel part of a 3D graphic environment, where he can move and interact in real time, with those objects and receive adequate responses according to the actions activated, such as new points of view movement of objects [2].

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1.2 Training/teaching and communication

In the past decades, the educational systems have appeared with frequent restructures as a result of inherent changes in the countries and of new psycho--pedagogical movements which value the student more: new rhythm of learning, adequate of subject matters to different age groups, development of cognitive aspects that transmitted in order to build different aspects of knowledge.

So, any type of communication consists in the transmission of a message to a receiver by someone who acts as message sender, with the minimum of loss of transmission. But, in order to have communication, the participants must use the same language and feel at ease with the transmission system for the technology to be a mean of effective communication.

The student, by having a virtual world, can explore it, see, touch, feel, manipulate it enthusiastically, discover a type of simulated game which lets a student learn in a motivated way by faces and simulation of the manufacturing process.

1.3 Virtual Reality and Multimedia Technologies

The conjugation of these two technologies [3] to construct the teaching model shown intends to be a new alternative to the conception of products for Computer Aided Teaching environments. By using simulation of virtual objects through computers and an interface between a developed application and the user, we want to create a product which favourably satisfies the items for which it was created, despite some differences between the essences of a Virtual Reality (V.R.) and a Multimedia System.

Although the V. R. system also process many data bases, the image constitution and its perspectives within that virtual world must be made in real time, with adequate program language and hardware where movement images are made.

However, and because the way of interaction with the objects creates by V. R. technology are still in increasing generalisation, namely the available peripheral, which satisfy the needs of moving objects and are largely diffused by the users/students, we must resort to a multimedia environment [4] so as to overcome, some of those inconvenience.

But in a larger sense, the conjugation of several existing media (image, sound, text and movement) in data bases will not lead to the creation of a new virtual world, but of multimedia environment to which it is intended. However, V. R. consists on the creation of new environments representation of a reality of the physical world, but in a way, that is much more participate on the part of the user in manipulation those virtual objects, where the multimedia techniques are part of those means [5].

2. Objects and Functionality

The fact that a Printed Circuit Board goes through over six dozens operations through its manufacturing process makes it a demanding product at the quality control level. Many of the mistakes made are a result of the users not knowing about the production of several items of the process. It is necessary to create one application which, in a tutorial way, leads and explains which basic measures to consider in order atoning those mistakes. The transmission of manufacturing techniques, in an interactive way, in the construction of various faces of the Printed Circuit Board is goal to reach.

Technologies such as Multimedia and V. R. are used where by combining sound, image, animation, text, interactive navigation lets the student have a learning system, possessing animation by movements, which the mouse will give the graphics scene depending on the object to be moved.

Students that have shown an extremely high tendency in using the system are using the actual application. We have collected some resulting data of some students which show a high level of understanding and high knowledge of the production cycle of the creates

Electronic System, especially in the building of Printed Circuit Board.

3. Production

3.1 System construction - model images

A typical user of CAD - computer aided design, is probably nom-existent. The needs for someone who projects Printed Circuit Board are different from those of heating equipment or ventilation engineer.

The conception of 3D objects goes through a process of modelling the entity to be represented, using basically a modelling system, AutoCAD [6], with the assistance of its 3D geometric modeller also called solids. The modelling of sections allows for the creation of two-dimensional (2D) areas, while in the modelling of solids proper three-dimensional volumes are created from the components (figure 1), where the student and monitors look for information they need in a dynamic way.

The integration of a section modeller in a solid modeller allows for the creation of solids from the regions and vice-versa. Due to the complexity of some entities to be represented, representation by layers of objects had to be used.

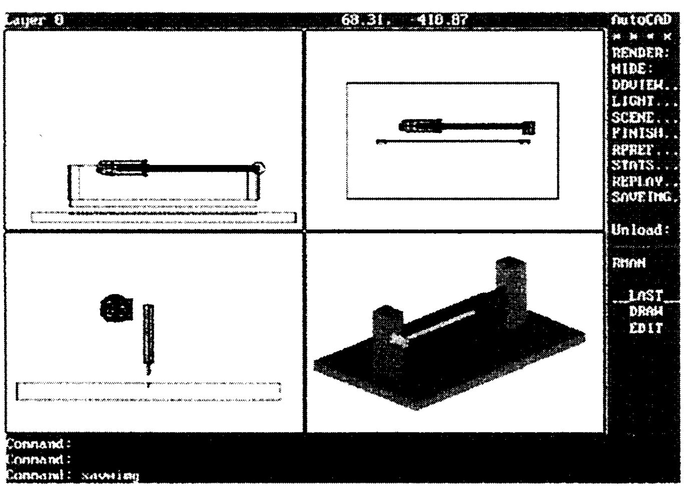


Fig. 1 - Three-dimensional modelling and filling out the component surfaces - Guillotine

The manipulation of solids geometry demands a good notion of space and a good orientation of work plan.

For the filling of surfaces, in the majority of parts/objects constructed and its animation for the creation of graphic scenes we used the 3DStudio [7] program.

Although both application come from the same manufactures, AutoDESK [7], there is no direct importation between the two applications mentioned, but normalised pattern of conversion must be used in this case DXF-Data Exchange File.

The graphic entities were organised by layers because it is the advised shape for converted objects in the 3DStudio.

In order to obtain the respective files in the 3DStudio, we proceeded to conversion using the following commands *File\Load*, by selecting the button *.DXF followed by the file.

Before continuing with the work, we save the file in format *.3DS by using *File\Save* commands.

3.2 Image and animation conception

As a second step in the system construction process and after the modelling of the various objects of each chapter constituting the construction mechanism of the Printed Circuit Boards there's thinned to place the adequate materials in the objects and give them movement.

By the 3DStudio application which is basically divided in five different fields which are the *3DEditor*, the *Shaper*, *3DLofter*, *Keyframer* and the *Materials Editor* we are able to simulate the behaviour of the mechanisms that make up the manufacturing system in their real shapers which are able to communicate to the student, through this environments, suitable knowledge for the functions we will have to learn.

The *Shaper* admits the creation of 2D geometry that serves as supported base for the *3DLofter*, the *3DEditor* and for the *Keyframer*.

The *3DLofter* works in 3D creation a series of special effects from the 2D geometry imported from the *Shaper*.

The *keyframer* produces animation; it has functions that admit work on the image in dynamic terms.

The *Materials Editor* works the appearance of the materials in terms of colours, brightness and transparency.

In the *3DEditor* we attributed light through the *Lights* menu various forms of light were used.

By means of cameras for better framing of scenes and in the menu camera there are several functions for an adjustment of the cameras to the objectives of this application.

In order to have realistic environments, it is necessary to have colours very close to reality. To do that we attribute materials to the objects using the *Materials Editor*. We can use materials from different libraries or create our own materials, when we work with materials containing *Mapping*, we go on to *Face Map*.

To give materials to the objects, we used function *Surfaces Materials Assign Objects*, after choosing the respective material.

To create animation, we used the *Keyframer,* which has specific functions to that end. When we enter in the *Keyframer*, everything that was created in the *3DEditor* shows up in the initial frame.

Also, we must alter the *Slider Frame* to the frame and the state of a certain object must be changed. We can alter the movement, the rotation, and the morphology and hide it. For a better control of this state, we use *Track Info,* which gives us complete information about the object through the frames.

To build the paths for the objects, we use the functions in the *Path* menu. The paths were created in *Shaper* and imported to the *Keyframer*.

To create the entity Robot movements, accessed through the respective icon/key on the main menu (figure 3) of the **Teaching System**, we used *Hierachy\Link* to connect the various objects.

The function *Hierachy\Center\Pivot* admits the modification of the object reference centre.

Before creating the final animation, we make an animation preview with the *Preview\Make,* which makes a sequence of monochromatic images of how definition to preview the type of created movements.

Preview creates an image, absent of colours and low defined. For the final animation we use *Render* menu function.

3.3 Virtual Interaction

As a way to integrated and manipulates the created virtual environments, we used the Cyberspace [8] program, a set of language of C and C++ [9] libraries.

As interface student system, we created a connection using the Delphi [10] multimedia program module.

We added a database, where we created the fields (image, animation, sound, information) of the chapters and the final presentation of the manufacturing steps (figure 2).

As extra information to the image, we have a text about that chapter for a better understanding of the process and easy relationship between the student and the different system functions.

Each register of the database coincides with a chapter where other faces of the process can be easily annexed.

We can navigate through the chapter with help of the *Objectdbnavigator* function which permits jumping from one chapter to another. The connection of the main program to the virtual environments is possible by the so-called *CreateProcess* function where the C++ libraries help to represent the objects.

We got, as result, a tutorial environment of the learning faces for the production of Printed Circuit Boards, widely used in projects of different areas in this institution and out.

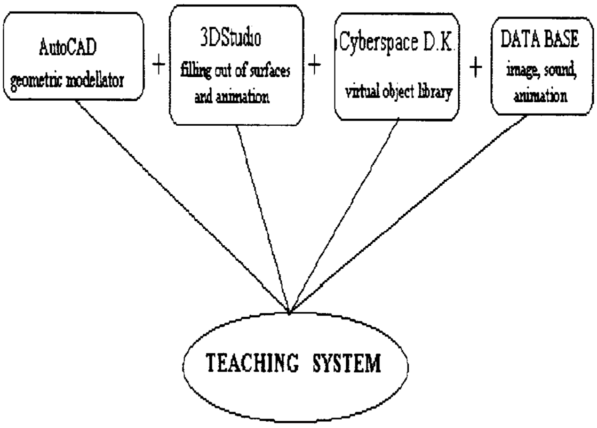


Fig. 2 - Connection of the used is developing systems.

4 - Operation

Initially the **Teaching System** presents an overview of the Printed Circuit Board (PCB) Production Lab and of the various sub-systems within the production process. A detailed view of each sub-process can be presented using the main menu (figure 3), which allows the choice of one the nine available chapter in the application. The chapters are tutorials with animated images and texts for each of the production processes involved:

1-Cutting: The PCB board is cut to the required dimensions.

2-Laminating: The board is covered with the photosensitive film.

3-Placement of the PCB drawing in the board: Centralise the PCB drawing in the required position within the board (figure 4).

4-UV lamp - Exposition of the board to UV light to impress the drawings.

5-Developping tank - The photo impressed drawing is developed.

6-Erosion tank - The copper outside the protected areas is removed.

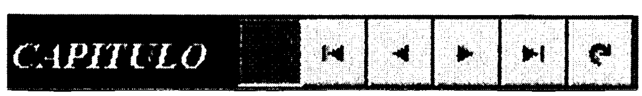
7-Scouring - The remaining protective film is removed.

8-Tinning tank - The copper tracks and pads are tinned and washed (figure 5).

9-Drilling machine - The holes on the board are drilled, for small works.

Fig. 3 - Main menu and 1st chapter of system
Cutting the PCB board

Within the main menu, the user can interact with the application through the use of two button bars allowing the navigation between chapters and the control of the animations. The supported options are:



- **Button bar to access the various chapters:** Moving to the beginning of present chapter, to the previous

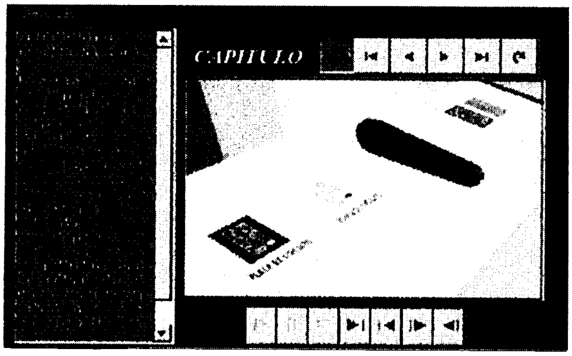


Fig. 4 - Centralization of Printed Circuit Boards

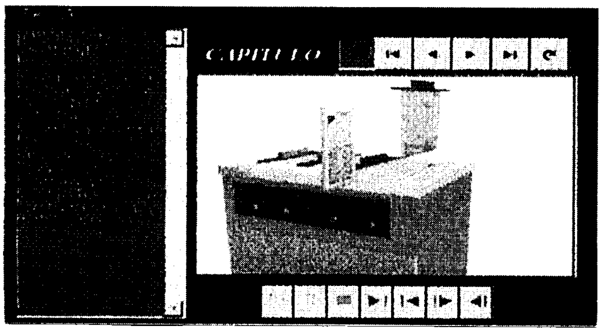
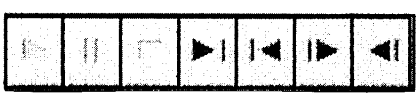


Fig. 5 - Tinning tank, operation of tinned and washed the tracks and pads

chapter, to the next chapter, to the end of present chapter and reload to refresh the screen.



- **Button bar to control the animation:** play, pause, stop, beginning, end, step forward, step back, to allow the control of the movement of the image ant to interact with it.
- Within the main menu window there is also a **Description** field - (Descrição) containing detailed information about the part of the process being visualised and a sound icon. In the lower border of the screen, there are six function buttons, namely: about, help, manual, robot, factory, exit:

- **About** - General information about the program.
- **Help** - Access to the help facilities of this application.
- **Manual** - Access the virtual PCB production lab in manual mode.
- **Robot** - Access the virtual PCB production lab in CIM mode (computer integrated manufacture).
- **Factory** - Access to the virtual environment of production area.
- **Exit** - Exit of the system.

4.1 Three dimensional virtual environments

The existence of three virtual environments (Manual, Robot and Factory) enables to visualize, train and interact, with the various stages of the product production.

- **1.Manual** it´s a PCB lab with the different components.
- **2. Robot** its an robot arm under a movable table and drilling machine (figure 6) for the machining of the board in an automatic way and this constitute a CIM system.
- **3.Factory** represent architecture of the production area in the PCB line.

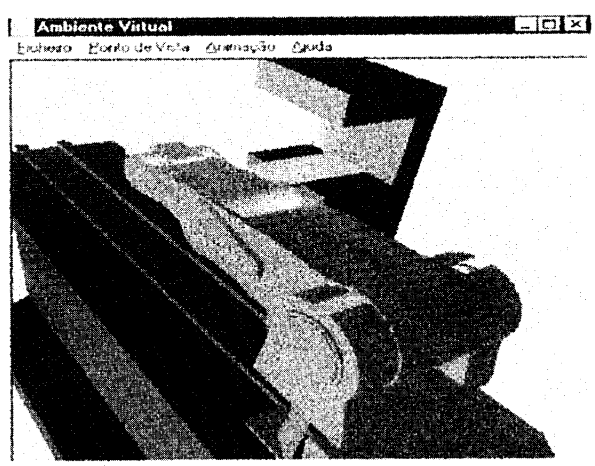


Fig. 6 - Virtual environment of CIM system with movements of robot by mouse interaction

Ficheiro Ponto de Vista Animação Ajuda

• **Button bar of the virtual environments:** the menu Ficheiro (file) its for to load a file and come back; the menu Ponto de Vista (point of view) its to reinitialise the camera of visualisation; the menu Animação (animation) its to create animation in front, back, stop and finally one Ajuda (help) to the user.

4.2 Icon Robot - navigation methodology

The simulation of the machinery process, put the board in the drilling table by the robot arm is doing in this virtual environment. The user can interact with the robot arm changing the path of the moving and perspectives of visualisation of the CIM group (robot, rolling table and drilling) by navigation of the manipulation of the peripheral mouse and through their moving and the click of the buttons, as same modes of operation, interacts with the objects represented to ahead the movements of this objects, examples:

• Icon of the mouse in the superior part of the window + right button: moving vertical plane to lowest part.

• Icon of the mouse in the superior part of the window + left button: moving in the horizontal plane.

The advantages to have this virtual environment CIM are relevance, when the user do not have the real appropriate equipment, for the realization of the stage of machinery process and the result in one module of simulation and global learning of all production system.

4.3 System Requirements

For one visualisation and performance of the present **Teaching System** are necessary the next requites minimum processor Pentium 166Mhz, memory RAM of 16Mb, graphic accelerator board at 2Mb, Windows 95 system or Windows NT and sound board.

5. Conclusion

In the near future we hope that this kind of environments of the different systems will have more potentialities in the connect of other peripheral for the manipulation. However we pretend to interact with the graphic objects and we successfully do it, by the moving of the mouse, in other to create the perception in the user, in their relation with the technology to learn, with a high performance than the traditionally systems, that have not interactive capacities. Then provoke certain monotony in the learning process and it does not raise the attention of the user so intensively, and so lowest levels of learning appear.

Relatively to the results ahead the users have a high level of learn, because they have a system were they are in permanent experimentation of the different stages of the building of the electronic boards.

In spite of a great complexity of systems of multimedia and virtual reality envelope it's possible to create a Teaching System, in use in Technologic High School, for to teach this disciplines and external courses, since that the students come from the local community.

At operation level the system are very friendly to use and lead the user to one precisely manipulation of the system to a fast learn of the production of the boards.

5.1 Future development

The introduction in the teaching system of news peripheral such as the data glove it will be a new stage of developing and it will be a future goal to expand the potentialities with news aspects of building boards and the evaluation of knowing. The systems will go to inside net systems to be use in remote areas of one factory or in he formation centres, through World Wide Web, they are same objectives to ahead.

Another improvement it will be the use of sound information associated to the peripheral that manipulate the object, also introduce the agent concept to create ergonomic interfaces for the user to chose which the menu, he will enjoy to work.

The work will continue as part of the first author Ph.D. level work on multimedia, virtual reality and interaction between human a machine on the learning processes.

References

[1] M. Gigante, Virtual Reality: Definitions, History and Applications in Virtual Reality Systems; Academic Press, Londres 1993.

[2] L. Camacho, Realidade Virtual e Educação, editor Hugin, Lisboa 1996.

[3] J. Vince, Virtual Reality Systems, Addison Wesley.

[4] J. Encarnação; J. Foley, Multimedia, Spring-Verlag, Berlin 1994.

[5] R. Kalawasky, The Science of Virtual Reality and Virtual Environments, Addison Wesley.

[6] AutoCAD r.12, AutoDesk, 1994.

[7] 3DStudio, AutoDesk, 1996.

[8] Cyberspace Developer Kit, AutoDesk, 1994.

[9] Microsof Visual C++ v.2, Makron Books, 1994.

[10] K. Henderson, Database Developers Guide with DEPHI 2, Borland Press, 1996.