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Construction, rehabilitation, and civil engineering education using 3D and VR model

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ABSTRACT:

It is reasonable to expect an engineering school to regularly update computational resources that are often used in the professions when it comes to instructional validity. In addition to three-dimensional (3D) modelling, virtual reality (VR) technology can be used to improve communication in professional settings, educational settings, and vocational training. Models pertaining to the building process were created using VR and 3D modelling techniques. The 3D models developed for rehabilitation design prove to be a valuable instrument for monitoring structural anomalies and supporting decisions made through visual analyses of potential remedies. The VR model developed to support building lighting system management enables the interactive and visual conveyance of data about the elements' physical behaviour as it relates to the time variable. Additionally, didactic interactive models depicting building operations were created. These programmes help with the study of the equipment required and how it operates on site, as well as enabling the visual simulation of the physical progression of each sort of operation. Students benefit from the introduction of CAD and VR approaches in the classroom because it helps them get ready to think of these technologies as valuable tools for their professional practice in the future.

INTRODUCTION:

In 3D computer graphics, **3D modeling** is the process of developing a mathematical coordinate-based representation of a surface of an object (inanimate or living) in three dimensions via specialized software by manipulating edges, vertices, and polygons in a simulated 3D space.

Three-dimensional (3D) models represent a physical body using a collection of points in 3D space, connected by various geometric entities such as triangles, lines, curved surfaces, etc.Being a collection of data (points and other information), 3D models can be created manually, algorithmically (procedural modeling), or by scanning. Their surfaces may be further defined with texture mapping.

We can trace the origins of 3D modeling to the 1960s. During this time, 3D modeling was a very restrictive domain where only professionals in engineering and automation could access softwares that worked on mathematical models. 3D modeling existed and showed promising signs, but restrictive access to the modeling systems and the cost of equipment kept it under the radar of many scientists and companies. Moreover, the modeling was highly complex and worked only with mathematical models. Not an ideal way for an artist to get involved.

This however changed, thanks to American engineer Ivan Sutherland who in his doctoral thesis project in the early 1960s introduced Sketchpad — one of the first graphical user interfaces.

The revolutionary new program allowed users to visualize and control program functions. It quickly became the base for developing computer graphics, operating systems and their interfaces, and software user interfaces.

Sutherland developed the first primitive version of the Sketchpad application in 1961. This application ran on TX-2, a programmable computer at MIT. After further experimentations, Sutherland published his doctoral thesis, "Sketchpad: A Man-Machine Graphical Communication System," in 1963.

ARCHITECTURE:

When we represent any object, we have the choice of drawing it "flat" (drawing) or as a "solid" (3D model). The results of the architectural design of a building are usually several drawings, which, lately, are often complemented by 3D models. Architects create 3D models of houses so that their clients can more clearly understand what the house will look like when built. Often customers do not have the technical skill and expertise to fully understand the 3D space arrangement of the house or building, just by looking to 2D drawings.

However, the history of computers in designing is very short when comparing to the evolution of traditional designing based on drawings and sketches by pencil and paper [12]. The development of Computer Aided Design (CAD) programs has been changing design methodology, at least in part. In general, designers approve of the use of CAD since because it improves designing, but mostly CAD is still used only as drawing aid. However, the process involved in design projects could easily derive clear benefits from the use of CAD because it can make drafting and the creation of alternatives quicker and more effective throughout several stages of designing, including the conception phase. For that, however, it is not enough for designers to learn to use CAD properly, they also have to learn how to create and to support their activity with it, which requires, also, a new way of thinking & reacting to CAD.

CONSTRUCTION:

Models concerning construction needs to be able to generate changes in the project geometry. The integration of geometric representations of a building together with scheduling data related to construction planning information is the bases of 4D (3D + time) models. Thus, in this field, 4D models combine 3D models with the project timeline, and VR technology has been used to render 4D models more realistic allowing interaction with the environment representing the construction site. The use of 4D models just linked with construction planning software or with virtual/interactive capacities, concerns essentially economic and administrative benefits as a way of presenting the animation of the expected situation of the work in several step of its evolution.4D models are being used to improve the production, analysis, design management and construction information in many phases and areas of construction projects . VTT Building Technology has been developing and implementing applications based on this technique providing better communication between the partners in a construction project. Note the contribution of VR to support conception design , to introduce the plan and to follow the progress of constructions .

The didactic VR models presented in the text shows the sequence of construction processes allowing step-by-step visualization. The models concern a wall, as a significant component of a building and two methods

of bridge construction, each with different degrees of detail and technical information. The target users of these models are Civil engineering student.Here,the VR technology was applied for educational purposes.

Fig 1: Perspectives of historic building 3D Model and alternative solution floor and stairs**.**

Rehabilitation:

Rehabilitation is a type of construction work where the final result is of utmost importance and which must be evaluated at a very early stage, before any decision or construction work becomes definitive. Two recent pieces of works related to Bologna master's theses were developed based on this technology. The students J. Neves and B. Martins had to learn 3D advanced modelling. In both cases, 3D models appear as an important tool for anomaly surveillance in the structures and for supporting decisions based on the visual analyses of alternative rehabilitation solutions :

■ Neves studied an historic building that was submitted to a rehabilitation process that includes the detection of structural anomalies, the replacement of damaged resistant elements and the adaptation of the building to new uses (Fig. 1). This application clearly demonstrated that the 3D geometric model allowed a quicker understanding of the structural organization of the building and a useful tool for the surveying and mapping of its damages.

■ Martins considered the installation of new sanitary equipment in an old building, which presents a significant degree of dilapidation. In this case, two alterative solutions were worked out and modelled (Fig. 2). By manipulating the models, the understanding

of the organization of the interior space is quite clear, better then that gained by just analyzing plan drawings. In both solutions the data for the sanitation system specifications, the quantity of pipe elements for hot and cold water supplies, the quantity and types of material applied to the interior surface of walls and on the floor were worked out. The 3D models helped work out this kind of data and also to identify incompatibilities in the introduction of new elements within old structures.

These situations contribute to the acceptance of the use of CAD, not only as a good “drawer”, but also as a useful tool in the analyses of rehabilitation work. Thus, teaching CAD in school induces students into

considering this technology as an important support for their later professional practice, and also enables the link between CAD systems and engineering theory.

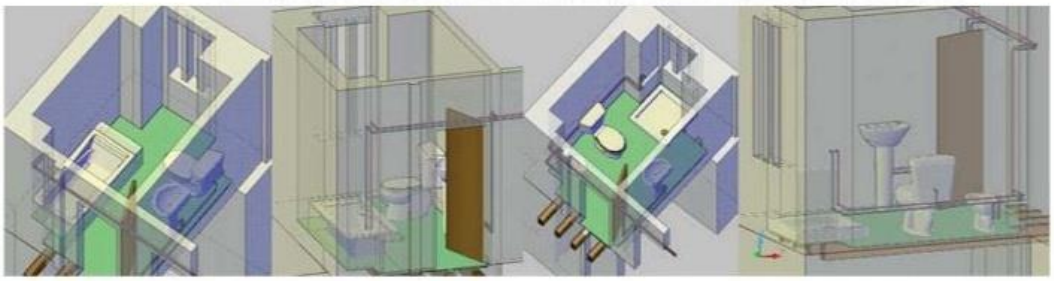

Fig 2:3D Model of two alternative solutions

Learning Aspects:

At present, the bridge models are used in face-to-face classes of subjects of Civil Engineering curricula: Construction Process (4th year) and Bridges (5th year). They are placed on the webpage for each subject thus being available for students to manipulate. The student should download the EON Viewer application available at http:// download.eonreality.com.

The traditional way to present the curricular subjects involved in those virtual models are 2D layouts or pictures. Now, the teacher interacts with the 3D models showing the construction sequence and the equipment operation concerning of the modelled type of work. Essentially, the models are used to introduce new subjects:

■ The deck bridge models show the complexity associated to the construction work of the deck and illustrate in detail the movement of the equipment. In class, the teacher must explain why the process must follow both sequence of steps and the way the equipment operates (Fig. 12). When the student, of the 5th year, goes to a real work site he can observe the complexity of the work and better understand the progression of construction previously explained;

■ The incremental method model presents a great complexity of geometry and material concerning the different elements used in a real work process. It provides an immersive capacity inherent in the virtual world and it has a menu of events which allows the students and teachers to select a specific part (Fig. 13). The camera movement shows the model in a consistent way to present all sequences of events allowing the user to see the most important details of this construction method;

■ The model was worked out attending both the technical knowledge and didactic aspects namely in how and what to show. It also attend that the model is going to be manipulated by undergraduate students of Civil Engineering. So, the model could be an important support to teachers to illustrate bridges construction issues in class and after, by themselves, using their PCs.techniques of VR more self-evident, especially when compared to the simple manipulation of complete models which cannot be broken down. The pedagogical aspects and technical concepts must be integral elements in the design and creation of these models.

CONCLUSION:

The paper has focussed on the importance of teaching CAD systems at school, not only as a good instrument for “drawings” but mostly as a helpful tool to be used to develop research work and, as a professional support in the activity of engineers.Regarding Bologna, two recent examples of 3D modelling were created to support rehabilitation design. The models were useful to the outcome of building anomaly surveillance and to workout alternative solutions. The VR model created to help the manage- ment of lighting systems in buildings was developed within a research project in school. It enables the visual and interactive transmission of information related to the physical behaviour of the elements, defined as a function of the time variable. Thus, teaching CAD and VR technologies in school may well induce students to consider this knowledge as elementals in their future professional activity, while to establishing the link between CAD systems and engineering theory.It has also been demonstrated, through the examples presented here, how the technology of VR can be used in the elaboration of teaching material of educational interest in the area of construction processes. The advantage of introducing new technologies into the creation of didactic material suitable for university students and technical instruction should be made known and applied. The didactic applications support the explanation of topics related to construction work. These models are used in disciplines involving construction and bridges in courses in Civil Engineering and Architecture. The main objective of the practical application of the didactic model is to support class-based learning. In addition, it can be used in distance training based on e-learning platform technology.There are many other possibilities for the creation of computa- tional models mainly where the subject matter is suitable for description along its sequential stages of development.

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