Rendering of Virtual Tours of Three Dimensional Model for Application in Higher Education

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ABSTRACT

This article proposes how to generate 3D virtual tours using the latest tools at the same time best practices and techniques in 3D rendering- tours oriented on its application in higher education are proposed. An analysis of the tools and techniques currently in use is required due to high demand in the construction of 3D virtual tours and its complexity, in which speed, complexity and the knowledge of these is crucial. It is a challenge for higher education training new generations of engineers in the use of these tools. Therefore, this article proposes the creation of best practices related to design, color, size and animation for the development of 3D tours that simulates phenomena related to specific topics grids of higher education institutions, in order to increase the competence and skills acquired in student learning.

Key words

3D Tours, rendering, computing processing,

1. Introduction

Nowadays the use of virtual elements that resemble reality through computer (3D models) has become a common practice in daily life activities and due to the large number of tasks that will be processed it becomes necessary to have computer equipment with better technical capacity. Besides with the incorporation of new technologies enable to perform this work without impacting the speed of the process and quality on results. Incorporating 3D tours on computers with higher capacities involves making overspending, factor that makes many institutions restrict their expectations to generate more relevant projects. According to [1] 3D model is a set of grids which can be represented geometrically in various ways besides having volume, color and texture.

Result of the foregoing the big question is: How to generate best practices for the development of 3D models and virtual tours?

According to [2], one possible answer is to use techniques, algorithms and validation mechanisms that contribute to improve the rendering. In turn [3] comments that the rendering process is the mechanism used to obtain an image from the description of a 3D scene

Today this process has reached a high level of realism where the main problem remains the execution time employee for it, the reason is that the algorithms used require a large amount of computational processing, it is therefore interesting to consider methods that reduce time spent on the rendering process, thus the importance of knowing which elements such as software, the rendering engine, the operating system of the model and virtual tour can combine in the best way to improve the performance. The creation of a three dimensional model follows a set of steps, according to [1], are: First, is given the way to the object through the use of polygons and other geometrical elements; Second, moves into the texturing and lighting stages, which are visual properties of object behavior against light, essential for the graph to be called 3D model; third, animation and rendering of the object in a scene. Once built the 3D model must be perform the steps of the process which allows us to build each frame to create a 3D animation or film, in order to generate the virtual tour, therefore is necessary that the used program to model builds a picture of the virtual camera that is displayed, the scene and move to the stage of rendering the frames of the timeline to get the dump into any video format.

2. Available Methods

3D reconstruction seeks to playback on a computer memory real objects, faithfully preserving their physical characteristics such as dimension, volume and shape. There are also in artificial vision, a variety of reconstruction methods whose main objective is to obtain

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an algorithm that is capable of connecting the set of representative points of object shape and surface elements as square or any other geometric shape, as shown in Figure 1.

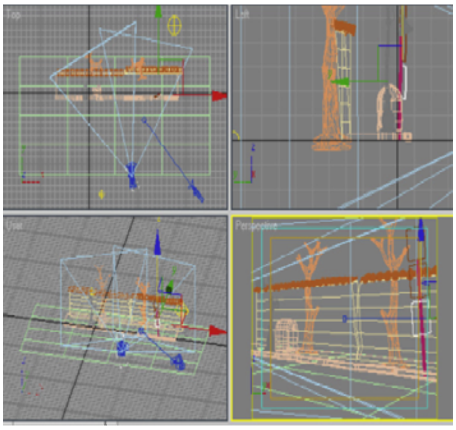

Figure 1. 3D model made in 3D Studio Max based on geometric shapes without textures.

To carry out the development of a virtual tour is necessary to have an uprising of the different requirements that will contain, such as:

- Dimension
- Tour of the animation
- Effects
- Time
- Stage lighting
- Cameras
- Dump (NTSC / PAL / SECAM)

As says [4], the problem of not having adequate representation
and reconstruction of 3D shapes the path of the animation and the photograms to be used has received tremendous attention on research programs in the last decade.
Therefore it is important to consider the following: frame is referred to a photogram, a particular image in a sequence of images which make up a timeline to create animation. The continuous succession of these photograms produce at the sight of the sensation of movement, a phenomenon given by the small differences between each one of them.
Frequency is the number of frames per second needed to create movement. Its formula is:

$$f(frames) = \frac{1}{T(s)}$$

Now, with this information we can understand that a video is a succession of images presented at a certain frequency. The human eye is able to distinguish approximately 20 images per second. Thus, when displaying more than 20 images per seconds possible to trick the eye and create the illusion of a moving image. The fluency of a video is characterized by the number of frames per second [5] (frame rate), expressed in fps.
Digital video consists on showing a sequence of digital images. Because these digital images are displayed at a certain frequency, it is possible to know the refresh rate, i.e. the number of bytes returned (or transferred) per unit of time. As mentioned by [6], a complete sequence of 128 frames of consecutive images of 500 x 292 pixels each one can take a maximum of 25 million fps. Thus, necessary frequency to display a video (in bytes per second) is the size of the image multiplied by the number of images per second. Consider a true color image (24 bits) with a resolution of 640 X 480 pixels. In order to show a video in the right way with this definition, it is necessary to show at least 30 frames per second, i.e. at a rate equivalent to: 900 KB * 30 = 27 MB/s.
There are numerous methods and algorithms with different characteristics and properties to the rendering process [7], [8], [9]. Can be observed in Figure 2 an image of a 3D model by applying a rendering engine which allows us to observe objects strongly attached to reality. Among the most popular engines today we have: V ray, Mental ray, POV Ray, among others.

Figure 2. 3D model developed in 3D Max Studio, Vray with elements and rendering

Making a 3D model resembles a real image as possible, depends on the rendering engine that is used, besides the software and operating system. Due to the development of different 3D models there are different software that enable us to develop 3D models and virtual tours, each of them can work with different operating systems combined with several rendering engines.

3. Methodology

Resultant 3D Object, must comply with requirements for application purposes. This model is an adecuate alternative in comparison with traditional infraestructure and software models of the global vendors, resulting in equivalent performance of rendering.
Table 1, is possible to see the different combinations that can work on some of them as: the operating system, software, 3D modeling and rendering engine.

Table 1. Combination of rendering engines based on 3D modeling software and operating system.

Sistema operativo	Software de modelado 3D	Motor de renderizado
Linux	Blender	Pov Ray V ray
Mac	Maya	FryRender FurryBall LightEngine3D:RayDiffuse Maxwell RenderPipe Turtle V-Ray
Windows	3D Studio Max	Maxwell Mental Ray Render Pipe V-Ray Voxel Render ShaderLight
Windows	Rhinoceros	Brazil r/s Flamingo 3D Maxwell Toucan Rhino Man VRay
Windows	Light Wave	FPrime KRay

4. Theory/Calculation

As says [10], in 1977 Mc. Call specifies a set of attributes that are used to measure software quality, which, in itself, is associated with "quality to the absence of defects" in the course of development and life of the software. These attributes are divided into:

- For the operation
- For review
- For the transition

Based on the tours generated, we take the McCall model indicators as a tool to define the quality of our prototypes of 3D models, as shown in Table 2. With this we can say that as good practice and benchmarking the tool with best indicators is 3D Studio Max.

Table 2. Comparison of 3D modeling software based on indicators of McCall model.

Software and O.S.	Maya Mac OS	3D Max Windows	Blender Linux	Rhinoceros Windows	Light Wave Windows
Easy to use		√		√	√
Integrity	√	√	√		√
Correction		√			
Reliability	√	√	√		√
Efficiency	√	√	√	√	√
Easy maintenance					
Test facility		√			
Flexibility		√			
Reusability	√	√	√	√	√
Interoperability	√				
Portability	√	√		√	

Meanwhile [11], proposes a model with different indicators to McCall model model which also helped us to measure quality in the development of our 3D prototypes that help us to know the advantages and disadvantages of using different programs as we can observe table 3.

Table 3. Comparison of 3D modeling software based on indicators of the model of Vega Rivera, Garcia.

Software and S.O.	Maya Mac OS	3D Max Windows	Blender Linux	Rhinoceros Windows	Light Wave Windows
Correction		√		√	√
Reability	√	√	√		√
Efficency	√	√		√	
Integrity	√	√	√		√
Easy to use		√		√	√
Easy maintenance					
Flexibility		√			
Test facility		√	√		
Portability		√	√	√	√
Reusability	√	√	√	√	
Easy Interoperability	√			√	

5. Results and Discussions

The exploratory nature of this study, certainly helps us to have a better overview of the process that involves the development of 3D models and virtual tours, and therefore the best combination of components as an alternative on the optimal generation of these routes.
Based on a virtual tour of a 3D model tests were performed, taking a total of 8 experiments and 5 replications of each one were made, in order to obtain the rendering time variation of a 3D model or virtual tour, relative to the established parameters. Each experiment was defined by specific characteristics such as, rendering engine, rendering technique and number of photograms, besides different combinations were made in order to develop the corresponding experiments.
Focus on conclusions about the behavior of the development of tours in a real environment, multiple test sets were applied. These sets of tests consisted on a series of experimental projects, where all tests have different quality parameters such as the rendering engine, rendering technique and number of frames.
To make the data obtained could be compared, it was decided that computers were used for testing had the same configuration, that all equipments have similar characteristics. To perform the experiments a 3D model was used with a final time of 1 minute 56 seconds, which was made up of textures, light, reflections, refractions, and motion of objects; to generate the animation two different rendering engines were tested, MentalRay, and Vray. Two different rendering techniques were used PhotonMaping and Scanline.
Table 4 shows the tests performed with different amounts of frames 12 frames per second and 25 frames per second. Note that these experiments were carried out to study the effects of two or more factors in the process of rendering 3D models. Thus we conclude that in general factorial designs are most efficient for this type of experiments. For factorial design is meant that investigates all possible combinations of factor levels in each trial or full replication of the experiment.

Table 4. Factors set for the different tests.

Test 1	Test 2	Test 3
Rendering engine: MentalRay	**Rendering engine** : MentalRay	**Rendering engine** : VRay
Technique: Scanline	Technique: Scanline	Technique : Scanline
Photogram : 12	Photogram : 24	Photogram : 12

Test 4	Test 5	Test 6
Rendering engine : MentalRay	**Rendering engine** : Vray	**Rendering engine** : VRay
Technique : PhotonMaping	Technique : Scanline	Technique : PhotonMaping
Photogram : 12	Photogram : 24	Photogram : 12

Test 7	Test 8
Rendering engine : MentalRay	**Rendering engine** : Vray
Technique : PhotonMaping	Technique : PhotonMaping
Photogram: 24	Photogram : 24

The effect of a factor is defined as the change in the response produced by a change in the factor level. Frequently this is known as main effect because it refers to the factors of primary interest of the experiment. The experiment that took place is 2K, Table 5 presents the data.

Table 5. Data from the tests.

Order	Run order	Central point	Blockes	Motor of Render	Frames	Technique	Time
2	1	1	1	Mentalray	12	Scanline	20.18
8	2	1	1	Mentalray	24	Photon	25.244
6	3	1	1	Mentalray	12	Photon	16.858
4	4	1	1	Mentalray	24	Scanline	28.452
3	5	1	1	Vray	24	Scanline	19.35
7	6	1	1	Vray	24	Photon	22.524
1	7	1	1	Vray	12	Scanline	30.538
5	8	1	1	Vray	12	Photon	26.318

Figure 3 indicates that we should use a combination of MentalRay rendering engine, with 12 fps and generating the rendering technique with PhotonMaping because this combination is the one that helps us to reduce render times, without being the most optimal, the best option is to use 24 fps to generate a quality animation.

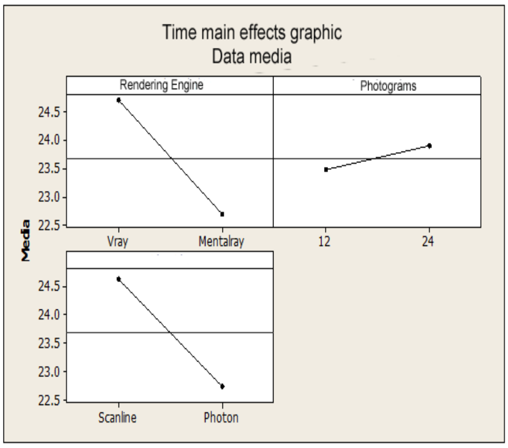

Figure 3. Time main effects.

In Figure 4, is possible to observe the time that it took to render 3D path testing, where concludes that there is a combination that enables us to determine what is the best composition of elements to generate an optimal rendering and decrease the time for it, and depends on the results according to scenarios, dump quality and desired output format.

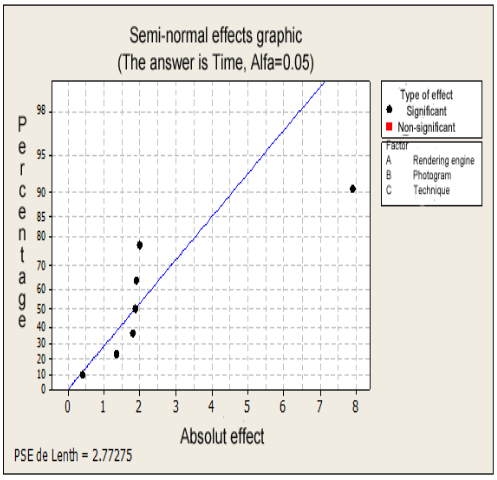

Figure 4. Semi normal effects.

To determine the factors that enable us to reduce the time takes to render an image or 3D model, we have three independent variables which are: rendering engine, number of frames and rendering technique.
After making the experiments and getting the results, is possible to determine that these are the main factors to decrease the time of this process, is known as well that other factors are also involved, but this is not part of the study.

This information is found in Figure 5.
Where is possible to observe that the best combination was Experiment 3. See Table 6

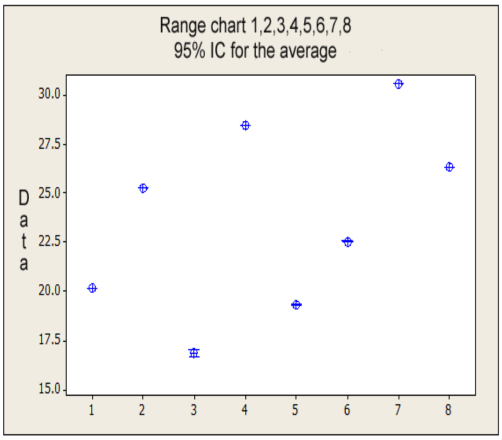

Figure 5. Intervals of experiments.

6. Conclusions

Once the experiments are done and obtained results we can determine which of the combinations established to perform the experiments is best suited to reduce the rendering time, but by looking at the data in Table 6, we notice that the data obtained are not significant enough to determine this.

Table 6.- Results of rendering time

Event	Test 1	Test 2	Test 3	Test 4	Test 5
1	20.19	20.18	20.18	20.17	20.18
2	25.23	25.23	25.25	25.25	25.26
3	17.09	17.03	17.03	16.58	16.56
4	28.45	28.46	28.45	28.45	28.45
5	19.38	19.36	19.36	19.34	19.31
6	22.58	22.5	22.51	22.51	22.52
7	30.56	30.57	30.52	30.52	30.52
8	26.34	26.32	26.31	26.31	26.31

Based on the comparisons generated in this study allows us to consider the necessity of using a standard process that covers all the steps required for the optimal development of 3D tours and allow us to generate best practices with best tools. We therefore propose a process that helps us to generate these routes, as shown in Figure 6.

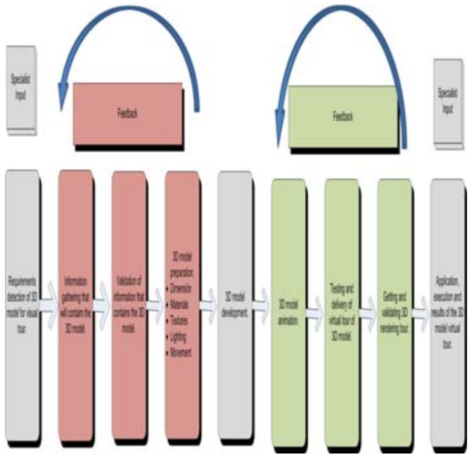

Figure 6. Model of development application 3D virtual tours.

Also is contemplated in the future another experiment taking into consideration other variables that help us determining the decrease in rendering time as well as different factors or parameters involved in the development of 3D tours.

Finally due to the application that will be applied in higher education, it is intended that the tours generated on 3D will be developed with didactic materials for its optimum performance in teaching and learning processes of the upper level, for example, teaching videos. Videos that will be available for both students and teachers everywhere and at all times (school, home, travel, public squares, etc.). To be accessible in several formats like mp4 3gp, among others, and would be viewable on a computer, tablet and even more mobile devices. As mentioned by [12] generated teaching videos are perfect material for display in mobile devices (smartphones iphone, Android and Windows) is currently working to provide the widest access to these resources through an appropriate diversification in the formats and media to be distributed.

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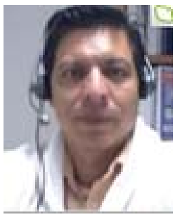

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