

## A NEW DESIGNING METHODOLOGY OF VIRTUAL TOUR

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*In this paper it is presented a new designing methodology of an on line virtual tour of complex structure containing many textures. This methodology allows to overcome some limitations of on-line models that are characterized by approximations and simplifications. These limitations are imposed by the great dimension of high quality projects related to the reconstruction of complex buildings and that slow down their development and diffusion.*

### 1. Introduction

The virtual tour through the internet of complex buildings containing many textures is limited by the great amount of data that have to be transferred through the net. In fact a high-level representation requires many polygons and large images as textures. For example, the representation with a 3d model of an important church in Bari 'The Basilica of Saint Nicola' is composed of about two hundred and fifty thousands of faces, more than half million triangles and more than one million vertices. The amount of the data that must be downloaded is very large, and present internet connections are not always sufficient. Moreover the object's description must pass through a process named "graphic pipeline" that visualize a 3D object on a bi-dimensional monitor. The simple pipeline's description reported in fig.1 is sufficient to understand that the number of polygons that compose the object has a great influence above rendering speed and on the fluidity of the visualization.

Then the problem we face in this paper is the design of complex tridimensional models, by using VRML language that is web3D oriented, that can visited through the net with a simple 3D browser. In this way it is possible to increase the number of people that can appreciate important monuments also at a great distance.

Infact these activities on the net, also if more and more desired, up to now have been limited by the dimension of the projects and long tour download time on standard internet connections.

In this paper it is presented a new designing methodology of an on line virtual tour of complex structure containing many textures. This methodology allows to overcome some limitations of on-line models that are characterized by approximations and simplifications.

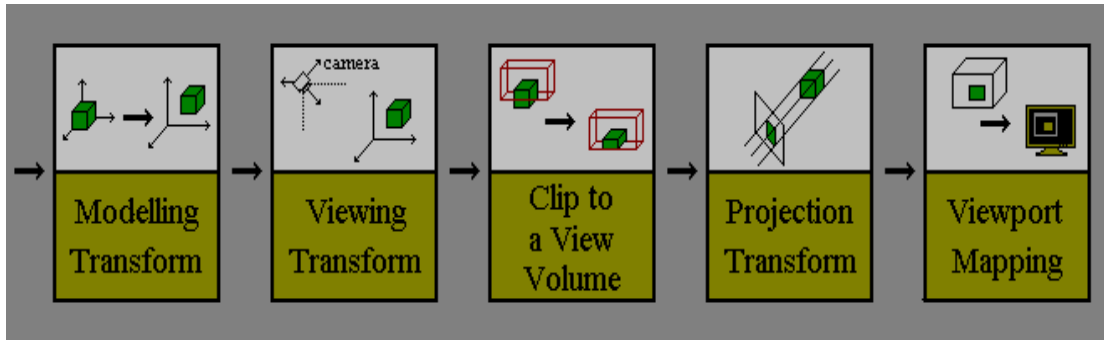


Figure 1

## 2. Simplifying models and keeping quality

The new methodology here presented aims to design complex 3d models with specific simplification of the realization that preserve the quality of the model. Briefly it consists in a optimal decomposition of the model, in the reuse of all possible objects and resources and the simplification of some specific type objects.

The first phase involve the 3d environment decomposition that has to be created in separate components. To understand the need of this decomposition it is sufficient to analyze the interpretation and projection mechanisms of a generic VRML Browser, that, basing on the Z-Buffer algorithm, generates the order in which each object must be projected in the virtual world so as to guarantee a correct reconstruction in respect of the observer viewpoint. It seems then necessary that the whole geometrical description of the environment is available before the video production and then the virtual tour.

The first part of the methodology here proposed consists of a specific designing phase in which the designer plans a suitable model decomposition. In this way it is possible to create separate and independent environments that allow to start the virtual tour before that the entire model is available on the remote computer and correctly interpreted. The second solution proposed concerns resources reuse that allows to produce once that architectural components that are repeated one or more times in the real object. It is then possible to prototype many part of the model whose description can be included in the final project just once. In this way prototypes of arcs, columns, windows an so on can be created and 'called' in the right position at any time. The reduction of the resulting file dimension is sensible without any intolerable loss of quality and, indirectly, also the reconstruction time benefits from this process.

Finally through the light simplification of useless components it is possible to reduce further the final dimension of the model file, obtaining a better virtual exploration in terms of fluid movements. The main base of this new methodology is the presence in many complex buildings of objects that, due to their vertical symmetry, do not change their aspects also if the observer point of view changes. For these objects we adopt description simulation by rotating around the y axis a plan geometrical figure.

The use of different textures quality, basing on the type of user network connection, is also adopted in order to obtain sufficient quality of the virtual tour for each type of user and connection.

### 3. Model designing

As we have already seen, project decomposition requires firstly the subdivision of the buildings in several modules, so as to reduce the download time, improve the quality of the tour and reduce waiting time.

The first decision concerns the starting point of the tour. After this it is possible and necessary to define the optical cone of the visitor, that is what he is able to look at from his current point of view. These simple operations make it possible to find and segment the module that has to be projected prior in respect to the resting ones. Project decomposition is then managed directly with VRML through *Inlines nodes* whose specification is reported in Figure 2. Inlines nodes are a special tool that allows to call sequentially external files and place them in the virtual world, basing on a unique coordinates system. It requires in the URL field the exact position where the module has to be placed.

```

Inline {
  exposedField MFString url []
  field SFVec3f bboxCenter 0 0 0
  field SFVec3f bboxSize -1 -1 -1
}
    
```

Figure 2

Resource reuse, as described before, allows to reduce project dimension by exploiting the components that are repeated in the real object. This solution can be applied by the combination of two VRML tools, that is Inlines nodes and *Transform nodes*. This last tool allows, basing on suitable rotation and translation fields, to place rightly the prototype in the scene.

```

Billboard {
  eventIn MFNode addChildren
  exposedField SFVec3f axisOfRotation x y z
  exposedField MFNode children []
}
    
```

Figure 3

The simplification of complex objects that present vertical symmetry, useful to reduce the reconstruction complexity is made possible by means of *BillBoard nodes*, whose specification is reported in figure 3. In detail, the field *children* indicates the shape that must be rotated, that is the plan figure that with its rotation will simulate the third dimension. The field *axisOfRotation* allows to specify on which axis the plan figure must be rotated.

The last solution that we apply to extend the possibility to visit on line complex monuments concerns the use of different quality textures. The quality and type of texture sent to the visitor varies basing on the network connection type. The different textures are obtained with different compression factor in standard encoding modality compatible with the web3d language used. About this matter we shown [11] that the use of variable textures does not influence the fluidity of the virtual tour considered as movements of the visitor.

In table 1 you can see a list of the VRML web 3d browsers that have been taken into consideration to evaluate the different behaviours when the techniques here proposed are applied to the model. They were analysed by measuring or verifying:

- Stability
- Rendering time
- Plug-in dimension and download time
- Model quality
- Fluidity of the tour

3d browser	Operating System		Browser		
	Win	Linux	Mac	IE	Netscape
<b>Cosmo Player</b>	√			√	√
<b>Cortona</b>	√		√	√	√
<b>Octaga</b>	√	√		√	√
<b>BlaxxunContact</b>	√			√	
<b>FreeWRL</b>		√	√		√
<b>OpenVRML</b>		√	√		√
<b>VRMLview</b>	√	√		√	

Table 1

#### 4. Experimental results

The first experimental results concerns the application of the techniques here proposed to a museum-site placed into the Athenaeum of the University of Bari that is named 'Salone degli Affreschi'. The first available evaluations concern the decomposition of the whole building in the components "perron", "aisle" e "hall". This decomposition allows to start the virtual tour loading firstly the module 'perron' that is the 19% of the whole model, and then have been downloaded the resting modules. In table 2 it can be seen the waiting times obtained by applying the model decomposition measured for different network connections.

Tipo di Connessione	Salone degli Affreschi	
	Intero	Scomposto
56K	620 sec	182 sec
128K	271 sec	81 sec
256K	135 sec	43 sec
384K	90 sec	25 sec
720K	48 sec	13 sec
1200K	29 sec	8 sec

Table 2

Tipo di Connessione	Salone degli Affreschi	
	Non Prot.	Prototip.
56K	182 sec	122 sec
128K	81 sec	54 sec
256K	43 sec	27 sec
384K	25 sec	18 sec
720K	13 sec	9 sec
1200K	8 sec	6 sec

Table 3

With the introduction of resource reusing the final model whole dimension was reduced to 66%, in fact the original dimension of 4.340 kb needed for the entire 3D reconstruction was reduced to 2.900 kb. The benefits are really evident and the waiting time are reported in table 3. With the use of Billboard nodes in the project here shown, further to the reduction of the project dimension and consequent reduction of download waiting time, it can be obtained a speed up of the rendering phase, and a more efficient use of system resources that allows to increase tour fluidity and global quality. Finally let us see the results reported in table 4, that reports the waiting time measured for textures that were compressed with 75% and 50% Compression Factor (FC).

Connessione	FC 100%	FC 75%	FC 50%
56k	122	90	63
128k	54	43	28
256k	27	21	15
384k	18	13	10
720k	9	8	5
1200k	6	5	3

Table 4 (seconds)

The main benefits deriving by the new methodology here proposed are more evident for slow network connection types. Really slow network connections will disappear in the next years but the full validity of the approach presented in this paper will remain constant; in fact it will allow to design and transmit via web more and more complex models, that in any case requires high network capacity.

Finally in in table 5 are reported the VRML web 3d browsers that have been taken into consideration to evaluate the different behaviours when the techniques here proposed are applied to the model. For the features strictly related to personal opinion it was chosen to use a 5-levels scale while for the rendering time was measured in seconds and the values reported in table 5 are mean the values obtained from five different tries. The Blaxxun Contact VRML Browser seems to be the solution that better exploits the benefits of the methodology here proposed, while a little problem is the dimension of its plug-in.

Plug-in	Blaxxun	Cortona	CosmoPlayer
Fluidità	√√√√√	√√	√
Tempi di Rendering	28''	59''	105''
Ottimizzazione memoria	√√√√√	√√√	√
Qualità	√√√√√	√√√√√	√√√√√
Stabilità	√√√√√	√√√√	√√√√
Dimensione in Kb	5.608	1.622	3.261

Table 5

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