VRML as a tool for the visualisation of numerical results obtained in the analysis of historical structures

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ABSTRACT: The numerical modelización of historical buildings represents an important tool for its knowledge, since it is of supreme importance to understand its structural behaviour for its conservation. At present, most of the computer programs of numerical simulation of buildings are divided in three parts: Pre-process (preparation of all the necessary information); analysis (development of the calculation) and Post-process (graphic tool that visualises the numerical results in form of colour ranges).

This work seeks to integrate calculation programmes with those of graphic representation in space. This way, the visualisation of the numerical results can be much more interesting. An interface has been developed as a tool for the visualisation of the numerical analysis of structures, which permits navigating virtually through any structure, to understand its behaviour and power to approach the problems or existent structural pathologies.

1 INTRODUCTION

The numerical modelización of historical buildings represents an important tool for its structural knowledge and this is important for its conservation. At present, most of the computer programmes of numerical simulation of architectural buildings are divided in three parts: the Pre-process, which prepares all the necessary information (geometry, border conditions, loads, and other); the Analysis, where all the calculations are developed and the Post-process, is the graphic tool that allows the numerical results to be visualised in form of colour ranges.

It is in the post process where the user of these programs meets with the difficulty of being able to make a detailed analysis of the results, since they are not observed in an agile and dynamic way. It is important to have graphic tools for the visualisation of the obtained results. For this reason, this work seeks to integrate calculation programmes with those of graphic representation in space. This way, the visualisation of the numerical results (forces, stresses and deformation values) can be much more interesting. Summarising, in this investigation the interface has been developed Sap2000-VRML as a tool for the visualisation of the numerical analysis of structures. This allows the users to navigate virtually through any structure and permits understanding their behaviour and this way, enables one to approach with more security the problems or structural pathologies presented the architectural structures in general, and in particular the historical ones. In this investigation a practical application on the Sacrarium of the Cathedral of the city of Mexico has been carried out.

2 INTERFACE SAP2000-VRML

This interface has as objective to generate a virtual world in format VRML being based on the numerical results provided by the programme Sap2000. With this transformation it is possible to visualise and to make a virtual journey of the built pattern.
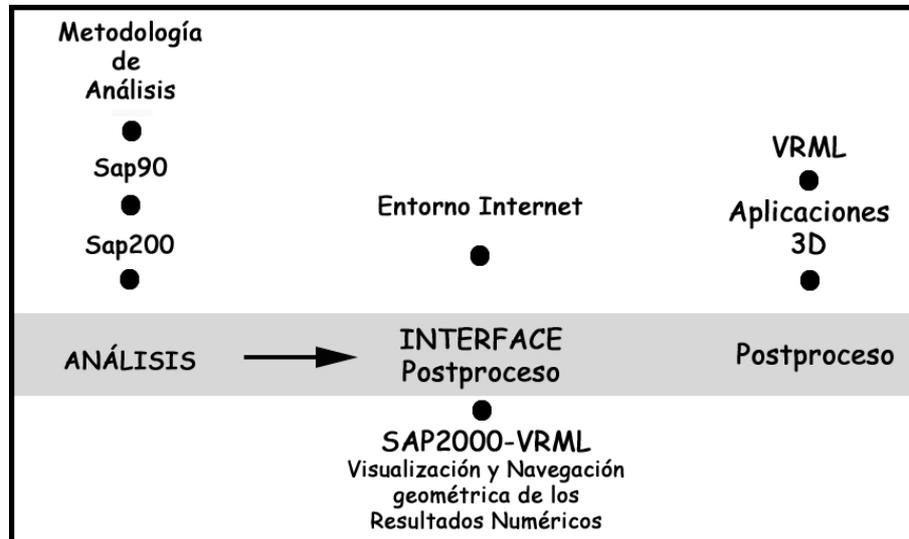

Figure 1: Interface Sap2000-VRML methodology

3 GENERATOR OF VIRTUAL WORLDS FOR INTERNET TO LEAVE OF THE DATA DE SAP2000.

The VRML format (Virtual Reality Modelling Language) it is one of the current standards for the distribution of three-dimensional models that not only reflects the geometry of the pattern, but rather it also allows to assign properties and behaviours as much in the pattern as in the form to visualise it and to navigate inside it. In this case the properties that are wanted to be reflected in the virtual pattern correspond in particular, to the obtained numerical values of any analysis generated by the programme Sap2000.

The interface of the programme was built in the environment of the development of Visual Basic, for the simplicity and speed characteristic in this environment.

4 METHODOLOGY

The conversion process goes by the following stages:

    4.1 reading of the data
    4.2 restructuring of the data
    4.3 writing of the VRML pattern
    4.4 writing of the HTML page that contains to the virtual world

4.1 Reading of the data

The entrance of data is taken starting from the files mallas.txt and forces.txt. of the first file, the relative information is extracted to the position of the vertexes that compose the pattern. Of the

second file, the definition of the polygons form the pattern of the object is obtained and the property of force associated to each one of the vertexes that compose it. Although the file forces.txt has a multitude of defined forces, in the reading process it is only read and stores that for which there is interest.
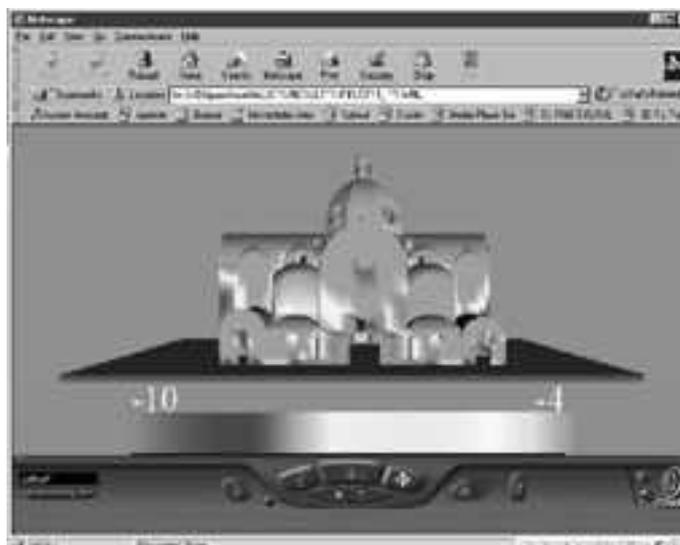

Figure 2: Numerical Virtualización in Internet environment

4.2 Restructuring of the data

To make the conversion it is necessary to make some changes in the organisation of the information. In the first place all the values of demarcation of the pattern settle down, as much in the geometry as in the properties. This means that the maximum and minimum values settle down in each one of the axes and in the selected force. With these values one will be able to adjust the scale, the location of the object and the range of values represented in the property of force.

Another adjustment that should be carried out is with respect to the value of the property in each vertex. The file forces.txt, defines these properties in an independent way for each one of the polygons that form the pattern, that assigns to one vertex different values of property depending the polygon to which it is associated.

To diminish the discontinuities taken place by this fact, it has been decided to associate to each vertex the average of the properties that it has associated in each one from the polygons to which it belongs.

In this way the vertexes that are interior in the mesh, will have 4 associate polygons and therefore their final value will be the average of the property in each one of them. On the other hand a vertex that is in a corner of the mesh, will only have an associated polygon and therefore it will not be necessary to make the average.
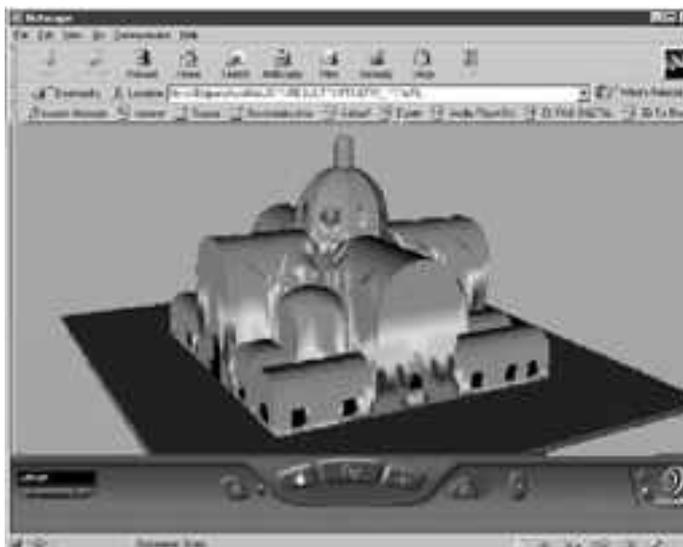
Figure 3: Visualisation in Internet environment

4.3 Writing of the pattern VRML

VRML, is a language to describe virtual worlds and therefore it should be adjusted to the syntax that defines the language. In this case the specification is using 2.0 of the language that it is the specification in vigour.

   The world that will build consists of several objects: the mesh of the pattern contributed by Sap2000, a reference plane on the one which to seat the pattern, the existent lights in the virtual world and the specifications of the observer's points of view.

   A VRML file has a hierarchical structure of a tree type for that, the first node contains the other ones and all that affects this will rebound in the secondary nodes.

   In this case starting from a group node the other nodes are added that will represent to the objects mentioned previously.

   Then they would follow the nodes that define the lights; in this case directional light is used.

Figure 4: Possibilities of virtual sailing inside the building.

Next a node comes to establish initial properties of the navigator and also a node to define a bottom colour in the virtual world.

The last nodes are those that define the objects to be visualised, the reference plane that it is built with geometric one of the primitive ones of the language (a box) the one which is defined as a node son of a node transformation. This is made to be able to place the reference plane in the appropriate place depending on the pattern to be visualised.

The node that represents the mesh of the pattern is quite long and therefore the parts will only be shown those compose it. Similarly as in order to the reference plane this object will have a node transformation that controls its position and orientation and inside that node a node is created formed by polygons. (IndexedFaceSet).
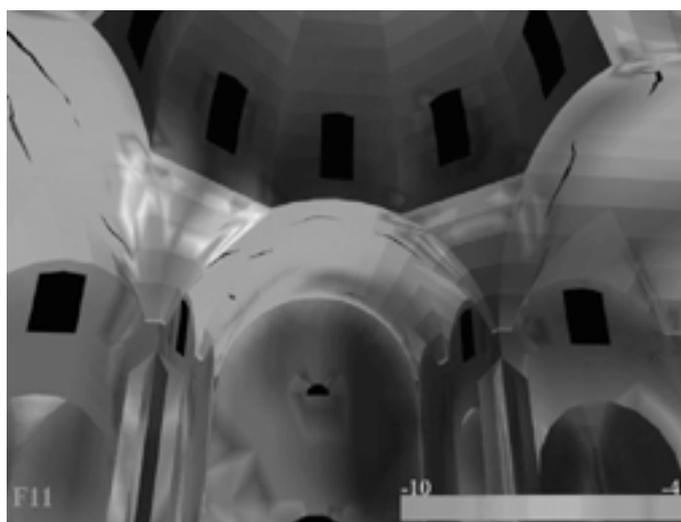

Figure 5: Inside the building.

4.4 Writing of the HTML page that contains to the virtual world

Besides the VRML file, a HTML file is attached, that is to say, a page web from where the VRML file is called. This is a step that is not necessary for the visualisation, since the Internet navigators can read the VRML file without necessity of this page. However, in the web page the scale of values is annexed that is being used and one could include more information with respect to the pattern.

5 IMPLEMENTATION OF THE PROGRAMME 3D STUDIO MAX TO GENERATE VIRTUAL JOURNEYS

3D Studio Max is a graphic programme, which transform a geometry assigning to this diverse textures; they are already in basic colours or like materials.

It allows renders with these textures, besides journeys, which transform them into videotape formats. Importing geometries in 3D in different graphic formats. One of them is the VRML.

For this investigation, it was decided that the implementation of the 3Dmax would be one more than the tools of graphic visualisation for the knowledge of the structural behaviour of the buildings; since it allows importing the obtained results of the interface Sap2000-VRML.

Starting from this implementation, the user can decide and generate punctual journeys that are of interest, inside the structure. With it, it is possible to visualise each space of the building.

Figure 6: Video of render of the numerical results in 3SDmax

As it has already been commented, starting from the VRML file generated with the interface Sap2000-VRML the user can define punctual journeys in function of the key areas that one wants to visualise. It is also possible to define different types and addresses of the illumination that it is wanted to assign to the pattern.

Figure 7: Animation of numerical results

6 CONCLUSIONS

The virtual space many times has more weight than the real one since it generates more complex perceptions. The interfaces developed in this investigation open a new form of analysis and knowledge of architectural, as well as historic structures. It is known that the historic buildings have a complex geometry and a difficult development. For this reason, this work is presented a new tool for all the professionals who are devoted to the study of the structural and geometric behaviour of any sort of building, as well as of the historical-architectural wealth of our world.

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