13th International Research/Expert Conference
"Trends in the Development of Machinery and Associated Technology"
TMT 2009, Hammamet, Tunisia, 16-21 October 2009

FROM CAD MODELS TO VIRTUAL REALITY SIMULATIONS: CATIA TO VR GEOMETRY AND DYNAMICS DATA TRANSLATION BY A VBA PLUG-IN APPROACH

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ABSTRACT

During last years more and more phases of the design process of new industrial products, such as Concept Design, Design for Maintainability or DMU-based Design Review have increased the use of Virtual Reality (VR) to achieve optimum outcomes in the product design process. On the other hand whilst major CAD systems have increased the support to VR interfaces and to advanced visualization systems, using specialized VR software gives still significant advantages in terms of functionalities, performance, flexibility and customization. Even so, a standard process for data exchange between CAD modelling and Virtual Reality simulations which combines the generality of standard formats with the information richness of proprietary ones is, to date, still far from coming up.

In this work we expose our approach to convert CATIA V5 models to our Virtual Reality software ViRstperson, which has been developed at the Italian Aerospace Research Centre (CIRA) over the last ten years. The software module developed to this purpose, named KinetiCAD, is a VBA plug in for CATIA V5 which walks the CATIA product tree by collecting the relevant information and 3D model data needed to generate a completely structured data-set to directly perform a VR simulation in ViRstperson.

Keywords: Virtual Reality, CAD, CATIA, VBA.

1. INTRODUCTION

The lack of interoperability between CAD systems and Virtual Reality (VR) systems is mainly due to the difficulty to efficiently import CAD data into VR simulations minimizing information loss. The most critical problem in data export is the different internal mathematical representation schemes. In particular, the problems arise from the accuracy criteria used when performing calculations with curves and surfaces. In fact CAD analytic models have to be converted into tessellated ones in order to perform real time realistic VR simulations. This can occur either within the original system or during the pre-processing phases of CAD data, performed with neutral format (IGES, STEP and s.o.).

Moreover, once the files conversion is completed, all the information, like reciprocal conjunctions and physical characteristics, that allows defining dynamics properties of the models which are the base for a physically-credible interaction among the objects into the virtual environment, result lost. [1,2,3,4]

2. FROM CATIA V5 TO VR SIMULATION: THE *KinetiCAD* VBA APPLICATION

In order to overcome this kind of problems, at CIRA VR laboratory it was developed a VBA application within CATIA V5, named *KinetiCAD*, that allows the user to generate a real time VR simulation directly from the CAD system without making use of external conversion software.

The KinetiCAD plug-in does generate a file set for the CIRA Virtual Reality system ViRstperson directly from the CAD CATIA V5 runtime environment (*source environment*). Once loaded a CATProduct in CATIA, KinetiCAD creates an internal representation by which it identifies both the hierarchical organization of the models (product tree) to be converted into a scene graph external representation and dynamics characteristics of the components (mass, centre of mass, inertia matrix).
The generation of the ViRstperson input files is carried out through the conversion of the CAD models, composing the CATIA product, into three-dimensional tessellated models (surface mesh). All kinematical properties (mass, inertia and s.o.), as well as all mutual connections, are translated in order to completely define a realistic dynamics simulation into the virtual environment.
The conversion process from the source environment to the virtual simulation is almost completely automatic, but it let the user to define and to set additional properties, or to customize others, in order to generate a tailored virtual simulation.

3. THE STRUCTURE OF KinetiCAD

Starting from CATIA CAD models, KinetiCAD generate an internal self-contained representation through the analysis of the hierarchical organization of the product tree and of visual (materials, colours, textures) and kinematical (masses, barycenters, matrix of inertia) characteristics and their integration into a global scene graph. The architecture of KinetiCAD is briefly depicted in figure 1.

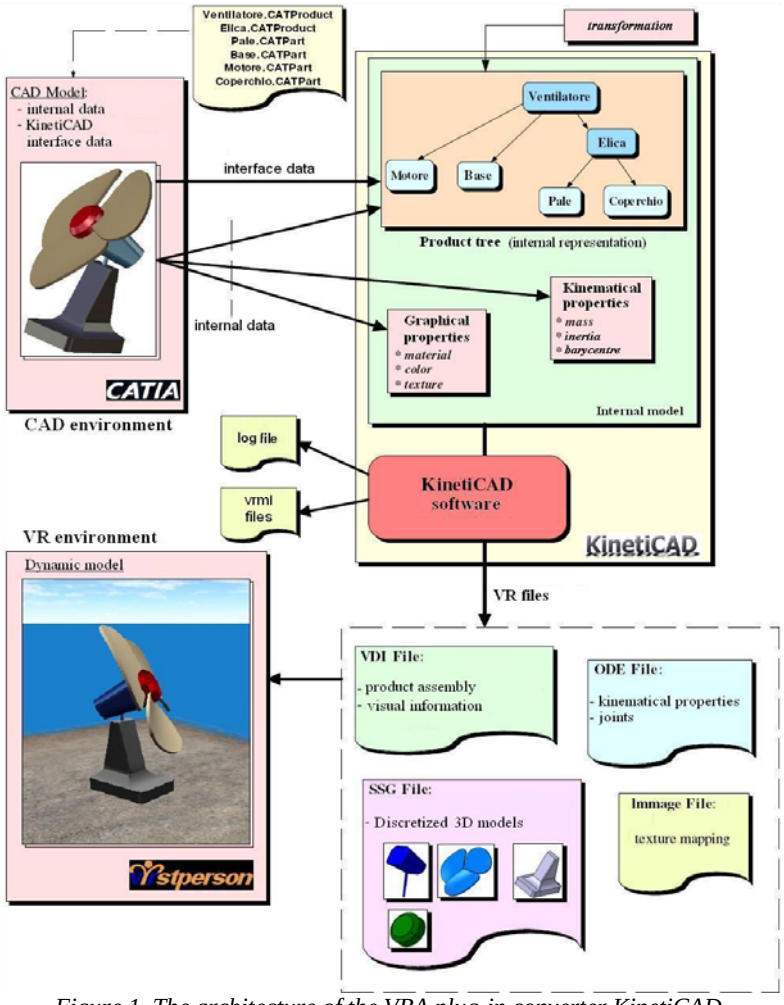

Figure 1. The architecture of the VBA plug-in converter KinetiCAD.

The example CAD model shown in figure 1 consists of four *CATParts* assembled in a *CATProduct* containing all the assembly information. Each node of the product tree contains information about the reference CATPart/Product and its position and orientation within the scene. In particular, the leaf nodes (figure 1) define the transformation of every single object whereas the transformations for nodes at intermediate hierarchical level (group node of the scene graph) are recursively applied to all child nodes. A global transformation can be applied to the product tree when the reference systems of CAD environment and of VR simulation are different. Figure 1 also shows the ViRstperson input files produced by the KinetiCAD conversion system:

- The SSG file contain all the geometric information of the 3D models considered (vertices, normals, texture coordinates and s.o.) as well as the possible transformations among the involved subparts. Conceptually the information contained in a SSG file are equivalent to the geometries contained in a CATIA CATPart file, whilst in a tessellated form. These files, that describe a reference geometry to be used as model to be instanced into the scene through a scene graph representation, are obtained through a VBA function that exports from CATIA V5 the corresponding temporary VRML files that are subsequently translated into the definitive SSG VR files.
- The VDI file defines an assembly and it provides the relative positions among the instances of the parts involved through the definition of relative positions and visual characteristics of the objects (colours, materials, textures and s. o.) organized into a scene graph structure of tasselled geometry. Conceptually the information contained in a VDI file are equivalent to the ones contained in a CATIA CATProduct file. These files are obtained through the interpretation of CATIA V5 constraints and their relative translation into ViRstperson joints.
- The ODE file specifies the parameters that the dynamics simulation needs such as the parts involved (body) and their masses, barycentres and matrix of inertia; moreover, here is possible to set all the parameters relative to the dynamics simulation of the ViRstperson and the characteristics and the parameters of the joints among virtual objects. All the CATPart/CATProduct files which are interactively selected as ViRstperson body get actually involved into the VR real time dynamics simulation.
- Image files are used by the graphics in order to visualize textured materials. Images are mapped upon the tessellated models through the use of the texture coordinates specified into the related SSG files.

The KinetiCAD GUI (figure 2) is the launching pad of all the module functions, which in turn is articulated in more than ten specific forms. KinetiCAD is also available as a standalone application based on the CATIA V5 COM server.

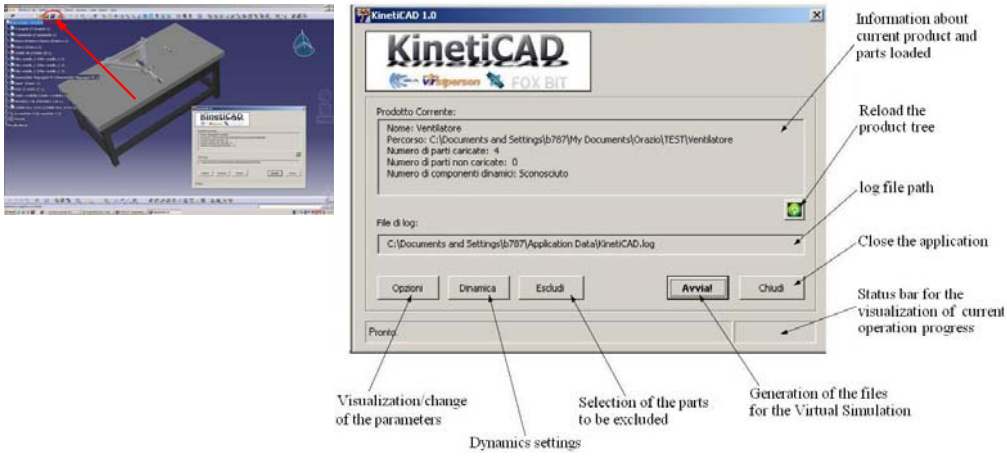

Figure 2. The GUI of KinetiCAD fully integrated within CATIA V5 user interface.

4. CONSIDERATIONS

The VBA approach to CAD-VR conversion results very helpful in generating VR real time simulations. In fact by this methodology it is possible to export the whole CAD design into a virtual scene without the need for the designer to use other external conversion software. The plug-in approach avoids complex and boring explicit intervention of data conversion and, above all, the user doesn't need to rebuild the virtual scene after the file export operations because all the reference systems, constraints and visual/dynamics information related to CAD objects are automatically exported into the virtual environment. Moreover the integration into the CATIA V5 user interface allows the designer to perceive the converter as integral part of the CAD system so that he could easily ignore the effort to learn to use a new application. Among other advantages, it doesn't depend on CAD file format, version, etc. as it is, instead, for third part command-line converters.
Finally, KinetiCAD only relies on VBA functions, which keeps the development effort low and facilitates its deployment to users. In the future the adoption of the CAA V5 C++ development environment could open wider possibilities, yet at significantly higher costs.

Figure 3. A ViRstperson VR simulation coming out from KinetiCAD.

5. LIMITATIONS AND FUTURE WORKS

Presently the conversion applies to the whole design so that even little changes in the CAD modeling requires to start a new conversion process, which could be onerous for complex assemblies. The next development step would be the analysis of the impact changes have on the product data so to limit the re-conversion to a minimum needed. Furthermore once the CAD-VR communication has been thus established a VR application could exploit the CAD modeling tools in a client-server mode, for instance the CSG ones, in order to carry out interactive tasks which actually modify geometries such as virtual drilling in assembly simulations. [5,6,7,8]

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