Virtual Reality as an Integral Part of Product Lifecycle Management (PLM)

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Abstract
Over the past decade companies have made major investments into virtual reality tools in product design, engineering and marketing, but the focus has been on the technology and the features of hard- and software. Little attention was given to the aspects of process integration. Consequently today, even industry leaders, lack a virtual reality process as part of their PLM strategy. Design data for the VR models, such as CAD files, material samples, configuration information and reference photography is collected from different systems and compiled in spread sheet tables before it is manually re-entered into VR tools for sales and marketing applications. This paper describes concepts and methods for fully integrating the digital prototyping processes and virtual reality models into existing PLM backbones to utilize the basic PLM technology for workflows, data administration and collaboration.

1. Introduction

Automotive and aerospace industry have taken the lead in applying visual simulation and Virtual Reality (VR) to their product design, engineering and marketing processes over the past decade. The initiative for introducing VR is mostly driven from the design departments. The focus is on functions and features to achieve the best possible visualization quality, but little to no attention is given to the aspects of integrating visual simulation into the product creation process and the IT infrastructure. This is partly because some creative minds in the design departments tend to consider processes as a hindrance to their work and not as a supporting factor.

Also, Product Lifecycle Management (PLM) systems were only at the very beginning when the automotive industry started applying visual simulation in their design departments and the PLM systems were designed to the needs of the engineering departments. Still today, there is very little acceptance of PLM systems in the design or marketing departments.

The situation is somewhat different in the area of functional performance simulation, which has been established in the engineering departments over the past two decades. Engineers tend to think more in processes and looked for ways to automate their work and administrate their data in product data management (PDM) systems from the very beginning.

With the growing demand for visual simulation, from the very early stages of product development all the way to the end of the product's life cycle, and with the progress being made by PLM systems and their increased acceptance in the design, engineering and marketing departments, today there is an opportunity to re-think the digital prototyping processes. It's time to make functional performance simulation and visual simulation an integral part of the PLM strategy.

The paper describes unique concepts and methods for integrating Virtual Reality software as an authoring tool into the PLM backbone for seamless digital prototyping processes along the complete product life cycle. Pre-requisite for the discussed concepts are open software tools, which can be fully integrated into existing PLM backbones, and a strategy of the VR software vendor, to design the software tools such that workflows can be automated to a maximum extent.

2. Simulation in the Product Creation Process

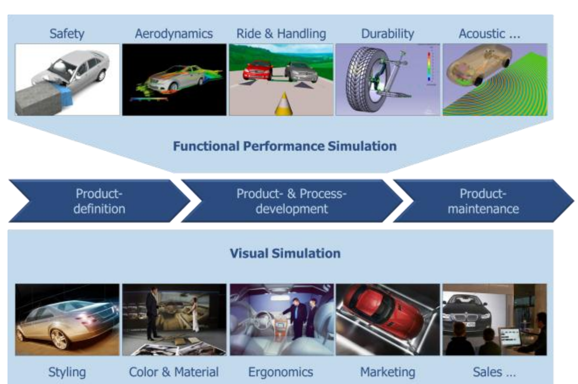

Figure 1: *Functional Performance Simulation and Visual Simulation attributes along the product creation process*

Computer simulation in the product creation process largely depends on geometric information and material data as the input for computation. Both, the functional performance simulation to evaluate product attributes like safety, handling, noise radiation etc. and the visual simulation to evaluate the products design and look rely on the CAD data representing the parts and assemblies.

In addition, functional performance simulation requires precise mass, stiffness, damping etc. parameters describing the physical properties of the material. Visual simulation depends on the material properties describing the surface treatment and finishing like color, grain structure, reflectivity etc. for a correct calculation of how the light in the virtual scene is reflected from each surface to achieve a photorealistic rendering of the product's look.

Basically any kind of computer aided design and computer aided simulation, be it in the early product definition phase, the product and process development phase or the product maintenance phase, depends on the products geometric data and the products material data. It seems to be obvious to administrate all this data in a central system - the PLM backbone - and make it available to everybody contributing to the product creation process. The data will be lean in the early stages of the product development process and become richer with every stage. Only by having all departments accessing the same data at all times, continuity and consistency in the simulation results can be guaranteed and product design changes can be automated.

3. VR-Process Status Quo

In the past we lacked the IT systems to make visual simulation a fully integrated and seamless process as part of the PLM strategy, today it's not a question of the IT systems but much rather a lack of a right vision and the will to enforce consistent processes across all departments contributing to the product creation process.

Consequently even industry leaders, who have embraced visual simulation as a part of their design and marketing process, still rely on a tedious and error prone process of manually collected data for the visual simulation from different systems, compiling the information in spread sheets and local files and then distributing the information packages to external companies for computer graphics (CG) productions.

Geometric information of the parts and assemblies typically comes from the PDM system, color and material samples and reference photography is stored in Enterprise Content Management (ECM) systems, and usually the information about the different product configuration for the different regions and markets is kept in the Enterprise Resource Planning (ERP) system by the sales and marketing organization. For the correct high-end visualization of the products for the different markets, all of this information is required in a well-structured format. Most times, the gathering of the data depends on personal networks of individual people in an organization rather than on a well-defined and structured process. Consequently, there is no workflow supporting system in place, no automatic updating procedures, no revision management and little control of the access rights of highly confidential data related to the company's latest developments and products.

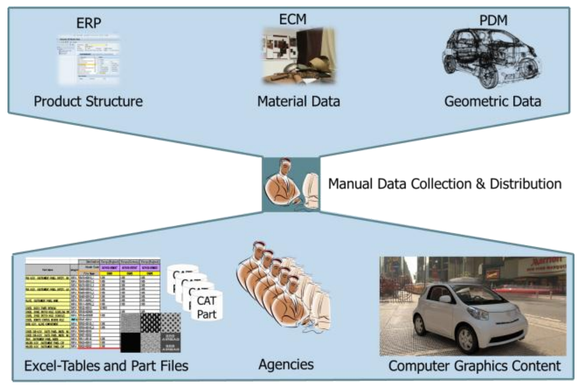

Figure 2: *Status quo industrial VR-Processes – in lack of system integration, data is manually collected from different sources and re-distributed without workflow support.*

Visionary industry leaders have realized that they are losing an unacceptable amount of time and money in this process and have started looking for alternative solutions. Fully integrating the virtual prototyping process into the PLM backbone looks like the most promising approach. This calls for a substantial investment into new software tools and IT services, as it has major implications on every stage of the product creation process. But once implemented, the return on the investment is huge, especially in the later stages of the process, i.e., for the sales and marketing applications.

4. VR-Integration into the PLM Backbone

Together with the PLM integrator ASCAD and the VR-software vendor PI-VR, nVIZ is developing and implementing concepts and methods for fully integrating the Virtual Reality process into the existing PLM backbone Teamcenter at B/S/H Bosch und Siemens Hausgeräte GmbH, starting from the early product definition phase all the way through to the product maintenance phase.

The CAD data is already available in the PLM system. New, to be developed and integrated into the PLM system, is a centralized material data base, which contains not only the physical material parameters for the functional performance simulation, but also all the parameters like color, grain, finishing etc., required by the VR shaders to photo realistically render the product in different environments. Besides the library of VR materials, the process also requires a library of VR scenes, which needs to be specific to each stage of the process and available to be loaded together with the product data by any department.

Usually, the design department will require standardized, neutral environments to be able to qualify a product's design without distraction by environmental influences of color and light. Standardization of the environments is also important in order to have a visual reference to a known physical environment. There is no way to judge the dimensions of a new product as long as it is isolated on a computer screen or powerwall. Only when positioned into a familiar environment the size becomes visible. For household appliance manufacturers, these environments will typically be standard and high-end European, Asian or American kitchens, each of which gives a different impression of a product's design.

Figure 1: *A VR-Process fully integrated into the PLM backbone utilizes the base technology of the PLM system for workflow support, updating and revision management, access rights control, collaboration and conferencing etc.*

The requirements for VR scenes from the marketing departments will be quite different. Marketing managers want to have their products featured in very emotional environments, reflecting the life style in the regions they sell to. Also, they have the need to automatically and 100% correctly configure the different products with all the different options for each region from their ERP system. Then place the virtual product into the environment of choice and produce images, animations and movies for the different sales and marketing media. All of this needs to be automated to the maximum extent to avoid manual work for repetitive jobs and free up time for creative tasks.

The core technologies behind the described process are:

(i) A dedicated VR data model being developed in the PLM system, which allows the VR specific data to be administrated in the PLM backbone with all the base technology of the PLM system like workflow support, revision control, update management, access rights control, collaboration and conferencing. The users can choose to access the data via graphical user interfaces, configured to the specific needs of each department, via thin clients, rich clients or WebDAV.

(ii) Very innovative VR software which is open to be integrated into the described process via an API and which fully supports automated workflows for the creation of a virtual product and the rendering of images and movies.

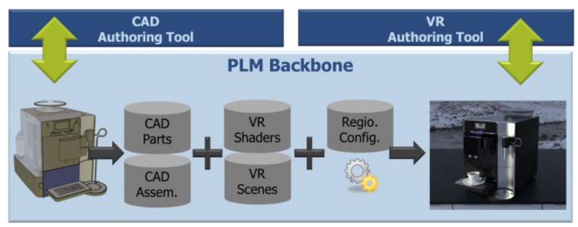

Figure 2: *VR-Software tools become authoring tools equal to the CAD and other software tools, all accessing consistent geometric data and material data in the PLM Backbone.*

The CAD software and the VR software become equal authoring tools in this process, both accessing the same data in the PLM backbone. The CAD tool is applied for design, modeling and material-ID assignment to each surface. Based on the information, as it is available in the implemented databases at any stage of the product creation process, the VR software serves as the authoring tool for high-end visualization. The VR scenes are automatically compiled from the geometry and material data in the PLM system and rendered by the VR authoring tool.

Frontloading will be a key factor for making the process most efficient. I.e., the earlier the complete VR material and VR scene information is made available in the process, the larger the return will be towards the end of the product creation process.

5. Return on Investments

In the early days of VR and booming economy, companies would invest into VR technology just for the hype of it. Today, every new VR project needs to go through a systematic analysis of what the Return on Investment (ROI) will be.

Especially in the extremely competitive automotive industry, with massive pressure to slash cost and time in the physical prototyping processes, the advantage of digital prototyping and VR is most obvious. Prototypes are extremely expensive; the availability in a quality for photo shootings with all the regional options is very rare and very late. Consequently, the ROI justification is pretty easy and straightforward.

The situation is somewhat different for manufactures of consumer goods. Physical prototyping is faster, less complex and less costly. Still the investment into VR hardware, VR software and IT services is huge and can easily amount to 2 Mio € for a global player. Payback is expected in no more than 3 years. This is a challenge for the ROI analysis. Considering only one stage of the product creation process, e.g., only the design applications or only the marketing applications, for the introduction of VR will not be sufficient. The required ROI will only be achieved with an approach, that takes into account visual simulation along the complete product creation process, from the product definition phase all the way through to the product maintenance phase.

6. New Technology Trends

A leading VR software vendor has just released NURBS based raytracing technology, which has the potential to redefine the VR process in all industries. Instead of first tessellating the surfaces for the raytracing computation and rendering, which is state of the art today, this brand new technology allows to directly raytrace and render the native NURBS surfaces from the CAD system.

On the one hand, this is a major step forward in terms of accuracy for visual simulation and physically correct rendering. Figure 5 illustrates the achievements in terms of accuracy, especially for close-ups. Depicted on the top, the classical raytracing based on tessellated geometry; the tessellation effects on the knobs are clearly visible and very annoying. Depicted below, application of NURBS-raytracing: no more jagged radii and 100% accurate rendering also in areas of high curvature.

On the other hand, the potential of this technology for process integration, as discussed afore, is probably even more important but needs yet to be exploited.

With the VR-software tools now directly accessing the native NURBS data of the CAD systems, there is no more need for tessellating and storing redundant geometric information. Also, with this technology, a seamless and bi-directional digital prototyping process comes into reach. The CAD system acts as the authoring tool for all aspects of modeling and geometric information. The VR system takes care of all aspects of materials and surface finishing. Both authoring tools administrate the same data in the common PLM backbone.

Figure 3: *State of the art raytracing technology based on tessellated geometry (left), versus NURBS-raytracing technology (right).*

Today, there are still limitations within the CAD systems, which do not allow for material references to be updated by the VR tool and then maintained in the CAD tool, but CAD vendors have announced appropriate functions for upcoming software releases.

Also, with the first market introduction of NURBS-raytracing in spring of 2010, there are still some limitations to the technology, namely in the area of texture mapping, as the uv-coordinates, the basis for texture mapping on tessellated geometry, are no longer available. But these limitations are expected to soon be overcome with new approaches in the upcoming software releases.

Also, the additional hardware requirements in terms of computer memory and CPU performance for rendering complete VR-scenes, based on NURBS-raytracing, compared to classical raytracing, will not compromise the spreading of this technology. The progressing trend of multi-CPU computers delivers sufficient compute power, and the advantages of a seamless virtual prototyping process is just too obvious, compared to the VR island solutions industry has in operation today.