

# *Building Virtual Reality Design System Based on DIVISION Mockup Software*

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**Abstract**—This paper dissertates the function of Virtual Reality Technology in the product development process, and discusses the advantage in building virtual reality design system with the PTC DIVISION Mockup software. The four key technology projects of building Virtual Reality Design system are explained simultaneously. In the virtual reality environment that is built with DIVISION Mockup Software, the virtual prototype of the Tunnel Boring Machinery is established and movement simulation is completed.

**Keywords**—virtual reality technology (VRT); mockup software; key technology solutions

## I. INTRODUCTION

In traditional mechanical design and manufacturing process, first, the concept of program design and plan demonstration will be completed, and then the product design is carried out. When the design has been completed, the physical prototype usually needs to be created for test. In order to verify the design, sometimes even these tests are destructive. When the defects in physical prototype were found out by experiment, the engineers need to modify the design and to make physical prototype again. Then, the engineers can verify the design further. Only through much more cycles that include design, making physical prototype and testing, the product performance would meet the user's requirement. This process of design and manufacturing is too long, especially for complex machinery systems. The traditional design process not only delay the design periods, but also can not adapt to the market's rapid response mechanism [1-3]. So with this traditional concept of the design and manufacture of machinery, it will increase the enterprises cost of design and manufacturing, and postpone the time of new products to enter market [4-5].

Being established in analyzing the overall performance of product, virtual reality technology (VRT) is a high technology, which can overcome the shortcomings in traditional process of designing and manufacturing [1-2]. In the environment of virtual reality, engineers firsthand employ geometry information and physics information of the various components provided in CAD system to establish the entire product lifelike image of 3-D digital model in computer. This 3-D digital model is called digital mockup (DMU)[6-8]. By using a variety of peripheral equipment, such as stereo glasses, gamepad, head mounted display, glove, 3-D mouse and flock of birds etc, the interaction between the user and model can be realized. Simultaneously, it can be actualized that complex product's displaying, kinematic analysis, assembly process simulating and simulating results in different test conditions. In addition, modifying design flaws in the computer is very easy. The design drawing would not stop being modified and improved until obtaining the optimal design scheme. Furthermore, the vision, hearing and other feedback information would be created, which make people same feeling as in real world. As an advanced design concept, virtual reality technology is a practical means in the field of machinery design and manufacture [6].

## II. THE CHARACTERISTIC OF THE VIRTUAL REALITY SYSTEM BEING BUILT WITH DIVISION MOCKUP SOFTWARE

There are a variety of CAD software including CATIA and UGS, which can be used to build a platform for virtual reality design system. Due to the PTC DIVISION Mockup software has many advantages which other software could not be provided with simultaneity, so the PTC DIVISION Mockup software would be used to build the platform for virtual reality design system [7-8]. Different types of CAD system have its own characteristics. It is key factor that how to utilize the CAD

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software characteristics and to build virtual reality design system that meets the special users' need.

As a better graphics and simulation software, DIVISION Mockup is widely used by many companies who lead manufacturing in the world. From conceptual design to integrated design and technical services, DIVISION Mockup is used throughout the entire life cycle of product. Using Mockup software to build a platform for virtual reality design system, the following main technical factors should be considered:

1) DIVISION Mockup is not only a graphical tool. It is based on real-time multi-processor core, supporting for multiple discrete events to operate in parallel. All modules of DIVISION Mockup are designed to have rapid response

mechanisms. When dealing with graphics, CPU can provide a mechanism of time allocation, which ensures that there are not any conflicts between simulation work and graphic data processing. This is the key point in application of virtual reality technology.

2) DIVISION Mockup has a high-performance and high-quality renderer that can support three-dimensional images and various forms of projective systems. Mockup can independently optimize the display performance of graphic while large-scale graphical data of model is processed.

Table 1 shows the difference between using PTC Mockup and CATIA software to build virtual reality design system [3-4][7-10].

TABLE I. THE DIFFERENCE BETWEEN USING PTC MOCKUP AND CATIA SOFTWARE TO BUILD VIRTUAL REALITY DESIGN SYSTEM

CAD Platform	DIVISION Mockup	CATIA DMU,Enovia DMU,DMU Navigator
Application direction	Very Large Scale Engineering Data	Medium-sized CATIA CAD Data
Capabilities for supporting heterogeneous CAD format	Dvconvert supports more than 10 formats of popular CAD input, Theorem Catia Converter supports CATIA data into a format Productview	Focus on the CATIA CAD data formats, but the latest version has improved
performance of Model graphics and maximum support capacity	Fast, for the VR environment and desktop applications for optimization, 64bit environment to support a large CAD model	General, for desktop applications could be optimized
Capacity of Graphic expansion	Active / Passive three-dimensional, multi-channel (SGI), flat / cylindrical / spherical screen	Using plug-in of Conduit, and does not support symmetric Video
Visual Material	support	supporting
Manikin tracking/user input	Entire manikin tracking (maximum / minimum manikin )	Using the plug-in of Conduit, the tracking of head and hands are implemented
Immersion interactivity	The technical support are provided by internal core of DIVISION Mockup	Not supporting
The engineering factor influencing between man and computer	Rapid Manikin, The tracking module of entire Manikin	Softwork Manikin
Behavioral Modeling and Simulation	Support various event triggered	Not supporting
Constraints	Support	Support, but need tools of CATIA Amechanism
Make animation sequence	Support	Support, but only can be realized in Delima environment
Real-time collaboration between multi-users	Support multiple users operating simultaneously	Support point-to-point operation
Scene Management	Landmark tool	Unknown
Interference checking	Using special algorithms, real-time checking	To use CATIA tools, could affect graphics performance
section/Measurement	Real-time dynamic measurement	Unknown

### III. THE SOLUTION OF ESTABLISHING VIRTUAL REALITY SYSTEM BASED ON DIVISION MOCKUP SOFTWARE

#### A. The solution of multi-purpose peripherals being connected with the virtual reality system

RapidVRM is an up-to-the-minute powerful interface that connects with DIVISION Mockup and Trackd[11]. The function of RapidVRM is that collect all signal of motion tracking system and interaction equipment. RapidVRM can support various types of immersive display systems to work synergistically, and helps application of DIVISION Mockup to complete tracking of six degrees of freedom and to realize the function of interaction immersion. RapidVRM can support all the interactive tracking equipments that are supported to work by Trackd to run. It can be realized that 'catching' object with virtual hands and 'operating controlling' event or scene with

gamepad, by connecting some peripheral (such as Data Glove , Gamepad , Flock of Birds, 3-D Mouse) with virtual environment with RapidVRM. The virtual reality system based on Mockup software can support many types of equipment (including 32 sensor units, 31 buttons, and 15 motion damping) to work at the same time. In addition, two special functions which include dynamic LOD controlling and tracking function are also provided in this solution.

#### B. The solution for real-time kinetics simulation results inputting

This is a multipurpose solution, in which the accurate numerical result of real-time simulation can be input in large digital assembly environment. In this solution, the calculation result is received from external simulation equipment (such as Matlab/Simulink) and is delivered to the DIVISION Mockup environment, in order to help control assembly motion model

and real-time events. The main purpose of this solution is to connect real-time accurate motion simulation results with visualization system of complex CAD model [12].

Communications is implemented between system and external simulators by using fixed/variable data streams. The fixed/variable data streams could be disorderly data, or could be orderly data flow that only has numeral. The key of communication is the variable value that corresponds with action function in the external simulators. Owing to each variable data types could be defined, the variables could be assigned accurately to action function. Each variable values has optional definition range that include maximum and minimum floating-point. The definition range can help action function in working state select the values in definition range.

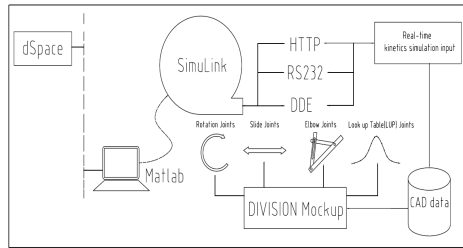


Figure 1. The solution for real-time kinetics simulation inputting

### C. The solution of human body tracking

There is a RapidManikin being called body function module in DIVISION Mockup software. In addition, this module can be invoked when Mockup is in working state. In DIVISION Mockup environment, the solution of a high performance for completely human body tracking vision immersed can be provided by RapidManikin module. Participants body position can be recorded and accurately measured by RapidManikin. These processes are recorded by standard Sequencer of Mockup software and replayed in real-time way. RapidManikin can work with all existing function module of Mockup's together. In studying of ergonomics, a virtual human body that has been quickly set and adjusted is put into data model of Mockup. By using RapidManikin module, the defect existing in the design would be found. The virtual human behavior results can be effectively recorded and replayed in order to research further in future.

RapidManikin module has important application on ergonomics research. Such as, testing the rationality of entrance for checking part, designing field of vision for vehicle, the interactivity among multiple users, and the collision behavior between virtual human body and digital model f, etc.

Because RapidManikin module was completely integrated into the DIVISION Mockup software, the model of the human body can be regarded as a kind of Mockup entity to manage, and for all the Mockup's tools to use. The same process of Mockup can manage multiple RapidManikin human models. In addition, multiple users can share a set of Vicon MX tracking system. If necessary, a single user can also record composite behavior. All these works can be finished in one Mockup environment.

### D. The solution for multiple users collaboration

This solution is also called 'a network configuration for true multi-user real-time collaboration system [13]. In the following example, all the processes of Mockup are associated. They share the same engineering model and interact between the processes and model. The behavior of each VR participant will be displayed through projection workstations. At the same time, VR participants and events enactment of 3D models scene can be controlled by projection workstations or desktop workstations. The tracking system or input devices defined by users also can be directly connected with projection workstation.

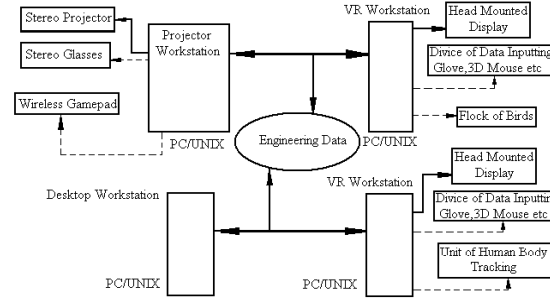


Figure 2. The solution for multi-user collaboration

## IV. EXAMPLE

Based on DIVISION Mockup software, the virtual reality design system was structured in our key laboratory. This system consists of hardware and software. The hardware includes SGI VSL80 graphics workstations, Christie three-dimensional projector, Flock of Birds, 3-D mouse, Head Mounted Displays, Stereographic CrystalEyes, and Virtual Technologies CyberGlove etc. The software includes DIVISION Mockup2000i2, RapidVRM, Tracked and Theorem etc.

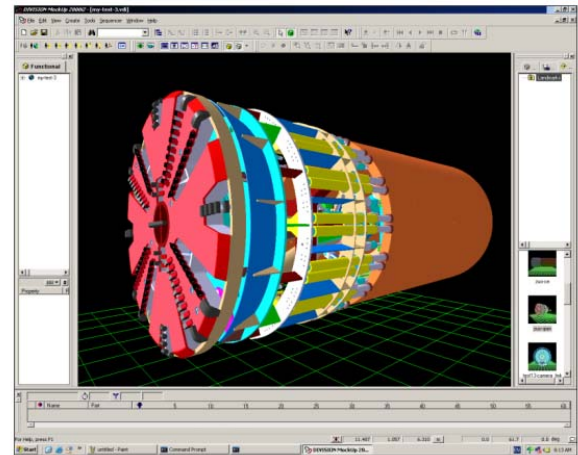


Figure 3. The virtual motion simulation of TBM's prototype in Mockup2000i2

In virtual reality environment that has been built in our laboratory, the simulation analysis of tunnel boring machinery (TBM) was completed. Without making the physical prototypes, all of the drawings of TBM, some geometry dimension of the parts and motion parameters are checked on and modified. The result shows the virtual simulation is suitable to development for new product. Compared with the traditional design method, using VRT to develop TBM can economize six months in development time and save about ¥ 1000 thousand yuan of capital. It has better engineering value and high economic benefits.

## V. CONCLUSION

At present, virtual reality design technology is one of the high-tech design methods. It not only can greatly shorten the product development period, improve design quality, reduce test and development costs; but also can decrease development risk. In constructing virtual reality design system, the choice of the CAD software platform must be thought over in the round. The above four key technical solutions should be grasped while the virtual reality design system is constructed with DIVISION Mockup software. Simultaneity, in order to construct virtual reality design system that meets enterprise's need, the reasonable selection of hardware and correct matching among the peripherals also should be considered. In such a way, it can play an important role in product research and development.

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