Research on the Three-dimensional Modeling and Optimization of a Virtual Tower Crane Based on 3DS Max, Solidworks and EON Professional

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Abstract: Three-dimensional modeling of virtual hoisting machinery is the critical works to structure the system of virtual construction, and the foundation to realize intelligent and interactive virtual hoisting. Aimed at enhancing the requests of image quality and stability of the virtual construction scene, taking a tower crane for example. We studied the technology of three-dimensional modeling and optimization of a virtual tower crane, and a method named two-stage model optimization was put forward. This depended on the modeling stage using Solidworks and 3DS Max and the performance optimization stage in EON. The practice of software development indicates that the proposed methods of three-dimensional modeling and optimization could satisfy the performance request of virtual construction system and be popularized to other virtual system.

Key words: 3DS Max; solidworks; EON Professional; virtual tower crane; three-dimensional modeling and optimization; virtual construction

1 Introduction

The research and development of a virtual hoisting system based on technologies of virtual reality, computer simulation, artificial intelligence, database and optimization decision-making is a hot subject applied to the domain of civil construction [1~4]. Three-dimensional modeling of every kind of construction object is the foundation of structuring the scene of virtual construction; the quality of the model directly decides performance of the virtual hoisting system such as trueness, real time browsing and velocity of interactive response. Hoisting machinery (mainly the tower crane, crawler crane and mobile crane) is an element of realization of microconstruction virtual simulation, and its characteristic of intelligent interaction determines the practicality and intellectualization of the virtual construction system so three-dimensional modeling and optimization are very important. Taking the tower crane for example, this paper puts forward and realizes the methods of modeling and optimization of a virtual tower crane based on 3DS Max, Solidworks and EON Professional, which could be spread to the structuring of virtual models of other hoisting machinery such as a mobile crane and crawler crane.

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2 Methods of structuring the model of a virtual tower crane

This paper and its following research work focus on the development of a prototype of the virtual tower crane based on EON Professional, which is an advanced software of structuring virtual reality application. The objective is to realize the virtual simulation of the hoisting process in the system of virtual construction, which has good intelligent and interactive characteristics. An American company named EON Reality developed EON Professional; this company is an advanced supplier in the domain of software and an integrated scheme of virtual reality. The relative soft-

ware of EON mainly include EON Studio, EON Professional, EON ICATCHER, EON SDK and so on. EON Professional is designed for a special developer and the physical modules of it, such as excellent Dynamics module and Collision Detection module are characteristic unlike other software. This could allow users to simulate a complicated multi-body system, the module of vision effect could supply the real time superlative trueness, and all these features urge EON Professional to realize the simulation of an industrial level.

The three-dimensional modeling is the foundation to build a scene of virtual simulation; models can be importid to EON and then develop designs and achieve interactive simulation. EON supports various file formats and provides an interface for importing. EON Raptor is a kind of plug-in unit of 3DS Max for exporting models to. eoz file format and then directly import to EON, so 3DS Max is a common tool for external modeling of EON.

The modeling of the virtual tower crane belongs to an entity modeling of mechanism production, while the lower accurate degree and assemblage efficiency of 3DS Max for industry and mechanism are its defects. By comparison, Solidworks is a major software for three-dimensional entity modeling of a mechanism; the higher accurate degree and assemblage efficiency are advantages and EON supplies import interface too, but the rendering effect of Solidworks is far less that of 3DS Max, and Solidworks hasn´t the tools for model optimization. Considering the relative merits of the two softwares for making full use of favorable characteristics, the modeling process of the virtual tower crane is illustrated by Figure 1 [4].

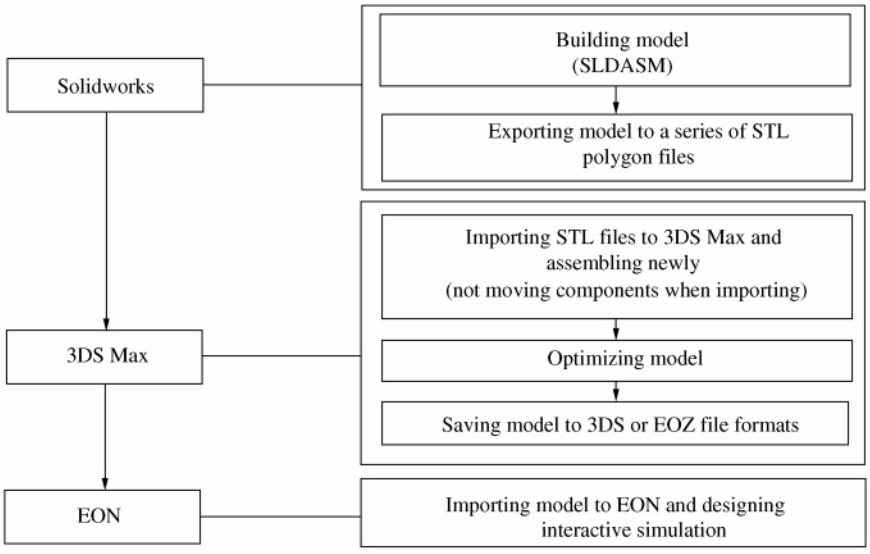


Figure 1 Modeling process of the virtual tower crane

3 Norms of modeling and methods of optimization based on solidworks, 3DS max

Due to requests for fast velocity of rendering (20 to 30 frames per second), smooth of real time interaction or browsing and short waiting time for user´s response, norms of modeling and technologies of optimization of a virtual scene is a hot subject of research. According to practice of development and optimization of a model of the virtual tower crane, this paper brings forward a method named two-stage model optimization which combines the modeling stage using solidworks and 3DS Max with the performance optimization stage in EON.

Although importing models structured by Solidworks to 3DS Max and then using the tool of mesh optimization to achieve a degree of optimization of model (mainly to shorten the numbers of polygon), confined to request of trueness of model in environment of virtual simula-

tion scene data size of the complex model is still larger and optimization could probably lead to some mistakes. Therefore, it is necessary to adopt some methods of optimization in the stage of modeling for advancing the quality of model optimization. Aimed at a virtual tower crane made up of many components and complex relations of assemblage, this paper provides some norms and methods of modeling:

1) Making models of different level of detail based on technology of Level of Detail for satisfying requirements of various tasks of loading the model dynamically. For example, when autonomous hoisting simulation is carrying out, the main objective is to demonstrate the hoisting path and motion of the virtual tower crane of autonomous planning and because the viewpoint is farther from the virtual tower crane, the simple model could be used. On the contrary, the detail model must be used when observing the structure closely and analyzing the mechanics characteristics and so on.

2) Reducing face numbers of model. Some faces of the model couldn't been seen in the simulation scene and have no influence to trueness of the model; therefore, these faces can be deleted to reduce face numbers. The mesh optimization tool of 3DS Max can shorten faces and the user should adjust the Face Threshold attribute repeatedly and observe the optimization result. The higher the value of Face Threshold, the more reduction of faces and in the end a suitable Face Threshold can be found to achieve optimization and couldn't lead to model distortion. The face number of the virtual tower crane in this paper is reduced to over seven hundred (Face Threshold is 20) by the face optimization and the model isn't distorted; importing the model to EON, it can be seen that the browsing effect is good and the velocity of rendering is faster. The 5th article studied and put forward some methods of modeling and optimization of 3DS Max, which could assist the optimization tool to advance quality and then further shorten the data size of the model file more [5].

3) In the simulation scene, some models are made to enhance the scene trueness but the interaction, in this case, these models can be shown by the way of textures and panoramas to lower the complexity of the model, such as buildings, surrounding environment and so on.

4) Reducing the number of models. On the premise of no influence to trueness, this paper reduces some components such as the dowel and bolt of the virtual tower crane, due to plenty of these components, so the number of models is reduced much more and the size of the model file is effectively depressed, accordingly.

5) The technology of DEF-USE can be applied to define same the objects of the model to simplify describing the file of the model and consequently relieves the burden of the browser and improves the velocity of rendering.

4 Performance optimization in EON [6]

Due to the high complexity of the model of a virtual tower crane, for further improving the velocity and effect of rendering of EON View, a kind of browser of EON, by way of deeply studying performance test and optimization tools of EON, this paper applies relative methods of performance optimization in EON for enhancing quality of model rendering.

Using EON Statistics to perfect simulation quality. By examining a simulation's statistics, a user can see if there are areas where time can be saved. Enable Show simulation statistics by activating the option in the Simulation menu or by clicking the Show simulation statistics toolbar button. The following information is displayed on the title bar of the Simulation window:

1) Hz: Number of frames per second. This is the average rate, calculated over several frames. A low value indicates that frames are being produced slowly.

2) frm: Time required to prepare a frame (in milliseconds). This value helps identify which frames consume the most time.

3) app: The time (in milliseconds) required for update calls. The number of nodes called is in parenthesis.

4) eve: Time spent on event processing (in milliseconds).

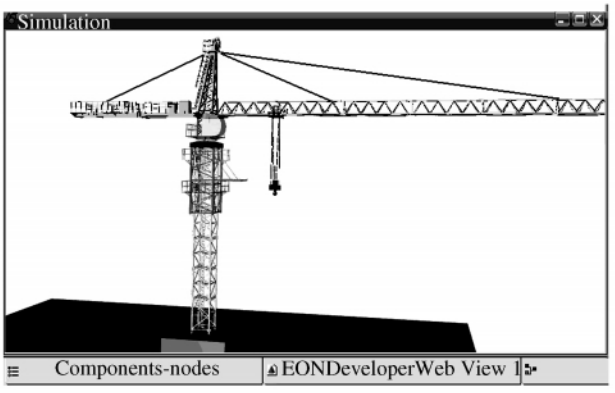
5) drw: Time spent on drawing (in milliseconds), including the loading of textures, pixel-fill, and vertex transformations.

6) #tri: Actual number of drawn triangles. Note that this number will change depending on the viewpoint. The velocity of browsing can be judged along with the change of statistics and suitable adjustment can be made.

The model of virtual tower crane structured by way of Figure1 is imported and further optimized in EON, a kind of hierarchical structure of simulation tree shown by Figure 2a) can be realized, Figure 2b) is a simple model made in EON directly. Some problems are discovered in the process of software development and it is necessary to stress:

1) Every component should be named in English or the phonetic alphabet of Chinese, otherwise, some errors probably appear while importing. Mesh nodes required by modeling couldn't be set up correctly. The seek path of texture files must be set, as for importing textures correctly.

2) After the importing process, in order to correctly achieve a joint kinematics relation between the main mechanism and following interaction design, collision detection and so on, the Frame and Group nodes are necessary to organize methodically all parts of the model of the virtual tower crane and complex construction scene by the parent-children hierarchical structure, modifying node's name to Chinese for identifying.



a) Detail model virtual tower crane based on structure of simulation tree

b) Simple model of virtual tower crane

Figure 2 Model of virtual tower crane in EON

5 Conclusions

With the development and popularization of technologies of soft hardware of virtual simulation, more and more virtual simulation systems will be developed and applied effectively in every field to assist employees to accomplish production and research work. In this system, the technology of three-dimensional modeling and optimization is very important; otherwise, virtual simulation would lose its significance. According as the domain characteristics of virtual simulation system developing, studying methods of modeling, choosing suitable software of three-dimensional modeling and a virtual simulation platform, studying the interface between softwares bring its merits into full play and improve efficiency and quality of model development. At the same time, researching optimization methods of the model to remedy shortages of software is also very significant. The following research work includes interactive or autonomous hoisting process simulation and collision detection of a virtual tower crane.

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