

# Research on Modeling of Virtual Simulation System for Digital Factory

Wenming Xia<sup>1</sup>, Lingyi Zhang<sup>1</sup>, Yuyan Zeng<sup>2</sup>

<sup>1</sup>School of Mechanical and Electrical and Mould Engineering, Taizhou Vocational College of Science and Technology, Key Laboratory of Mold Intelligent Manufacturing of Taizhou, Taizhou, 318020, China

<sup>2</sup>Taizhou Henglan Plastic Mold Co., LTD., Taizhou, 318020, China

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**Abstract:** Digital factory system platform is a virtual production line simulation environment based on the concept of digital factory and using computer technology, VR technology, network technology and other related technologies. The software platform based on simulation technology, because of the visualization of its process and results, enables users to understand intuitively. According to different requirements, the software required by digital factories is also different. On the basis of analyzing the structural characteristics and operation mode of the manufacturing system, combining the object-oriented design method with the virtual simulation technology, the modeling mechanism and implementation method of 3D visual graphic simulation oriented to the manufacturing process are proposed. This system realizes roaming, monitoring, real-time state simulation and scene setting.

## 1. Introduction

With the increasingly fierce market competition and accelerated updating speed, the degree of automation of the production process is getting higher and higher, and the complexity of the production process is getting higher and higher. Virtual factory technology provides strong support for simulation and analysis in product design, manufacturing and management, and is one of the basic technologies of enterprise informatization [1-2]. In recent years, with the development of digital technology, virtual simulation technology has become a new and more effective simulation means. The traditional industrial virtual simulation is mainly about assembly line planning, simulation animation demonstration and other demonstration functions for enterprises.

The realization of digital factory is bound to be a long-term process with the development of the company, which is mainly manifested in the following aspects: the application of virtual factory technology and the application of digital technology of physical production system will be more and more in-depth, mutual penetration and finally integration. In the simulation process, the object-oriented technology and 3D modeling technology are introduced, which greatly improves the modeling environment, improves the modeling speed, and reduces the requirements for the user's operation level [4-5]. On the basis of analyzing the structural characteristics and operation mode of the manufacturing system, combining the object-oriented design method with the virtual simulation technology, the modeling mechanism and implementation method of 3D visual graphic simulation oriented to the manufacturing process are proposed.

## 2. Overall modeling of virtual simulation system

Digital factory system platform is a virtual production line simulation environment based on the concept of digital factory and using computer technology, VR technology, network technology and other related technologies. Digital factory system includes software and hardware. Digital factory technology refers to the practical technology used in the construction of digital factory, which is an organic combination of computer technology, VR technology, simulation technology, network technology and ergonomics technology [6].

In virtual motion simulation, the simulation based on measured values can be divided into displacement/rotation simulation and angular velocity simulation. The collected real-time

displacement data is a discrete position point. In order to ensure the continuity of the model motion, a path node is set at the front and back coordinate points of the object motion and the path inflection point, and other coordinate points of the object in motion are obtained by linear interpolation, and then the motion trajectory of the object is obtained by combining these coordinate points [7]. Finally, the 3D model is visualized by Unity3D technology.

In a sense, a factory is a part of an enterprise, and its core business is responsible for the production, processing, manufacturing and inspection of the enterprise [8]. In the process of digital production, the integrated enterprise model is adopted as the reference model. Virtual machine machining system mainly simulates the machining process with virtual machine tool as the main body, and it is necessary to establish control system module, machine tool motion simulation module, machining process module and so on, and combine them organically. The overall model of the virtual machine processing system is shown in Figure 1.

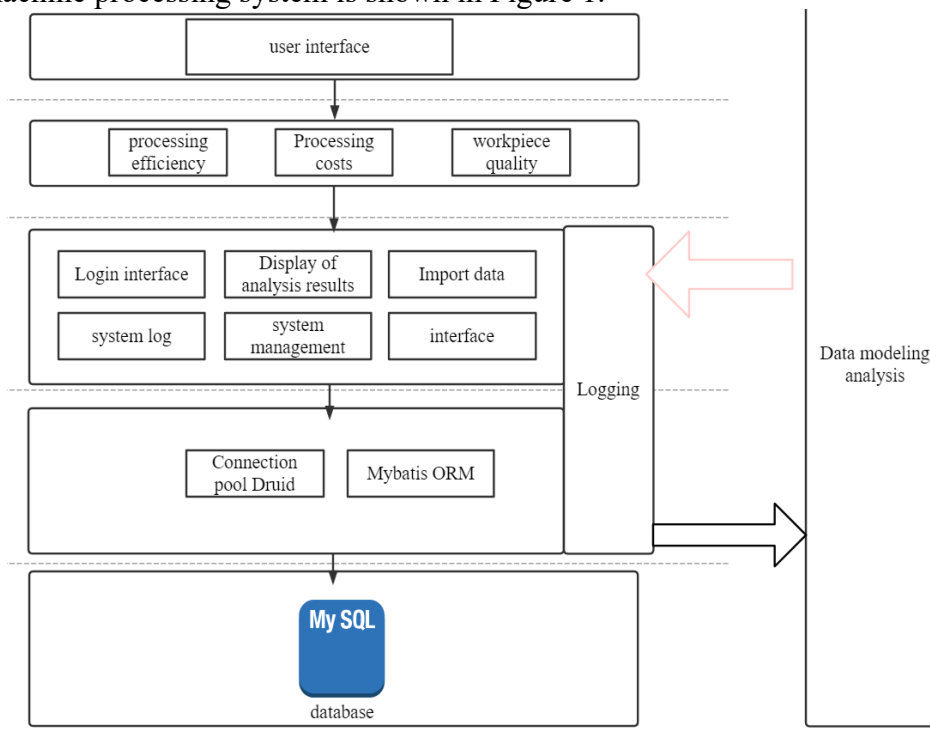


Figure 1 Overall modeling of virtual simulation system

Similar to the actual machine tool, the virtual machine tool module can also be regarded as a set of interconnected movable parts, which can be processed by relative motion. The module software can automatically collect the instantaneous parameters of workpieces and tools, and can simulate the machine tool to process workpieces. Then, on this basis, the related business attributes, rules and time limits are configured and applied in the enterprise. This project intends to establish a workflow view by establishing a workflow process model, integrating models of products, resources, organizations, functions and information, so as to realize the unified expression of views, so as to reduce the losses caused by the continuous transformation of models and the loss of information.

### 3. 3D modeling

Digital factory technology was born in the information age and has experienced a series of development and improvement. Digital factory is based on the principle of virtual manufacturing, which realizes static factory, logistics simulation and assembly process planning by using computer technology and network technology through virtual product development environment. In the process of factory construction, it is a revolution to the traditional factory planning concept to optimize the process layout and logistics scheme, shorten the construction period and reduce the cost [9]. The software platform based on simulation technology, because of the visualization of its

process and results, enables users to understand intuitively. According to different requirements, the software required by digital factories is also different.

In the 3D models used in this paper, all the models are built by Maya, and the logic control class is used to represent the logical relationship between objects. Simulation support classes are used to describe simulation support, such as time, events and statistics [10]. For example, the entity attributes mainly include the number of equipment, the name of the equipment, the specifications of the equipment, the original price, the geometric shape of the appearance, the size and color of the appearance, etc. Function attributes include the specified size, quantity, capacity, and the amount of work or materials provided.

Geometric modeling is the most basic and important step in the development of virtual reality. In this process, geometric modeling can obtain geometric models that describe the appearance and shape information of objects. It includes data structures for storing appearance and shape information, and various geometric model transformation algorithms. Therefore, starting from the manufacturing environment of the production system, using the object-oriented modeling design method, the class is abstracted into four basic object classes: equipment class, product class, control class and event class. On this basis, a new method for product development is proposed. As can be seen in Figure 2:

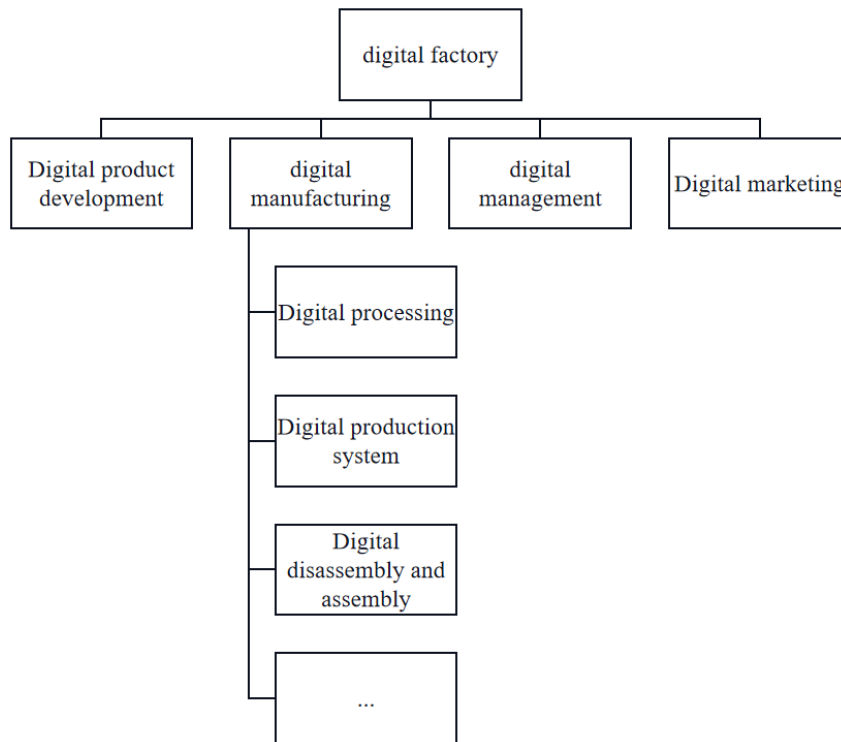


Figure 2 Digital factory composition

In order to shorten the time of user modeling, users can easily and intuitively simulate the system. The system uses graphic modeling technology to help modeling, and based on VC OpenGL technology, the 3D modeling VC OpenGL environment is completed on the development platform. Each simulation mode can be divided into two categories: one is entity mode, and the other is logic mode. A solid model is a 3D geometry representing the simulation results. The system also includes several geometric data conversion interfaces, which can read out common geometric model files and store STL DXF 3DS OpenGL storage through the display list mechanism. When necessary, the display list can be directly called, which can improve the drawing speed of the scene.

The simulation driving data in the virtual simulation system mainly comes from various heterogeneous data collection systems, such as SCADA system and AGV control system. Different types of data have different characteristics, such as the definition method of data structure, the format of data coding and the quality of service requirements of data.

The overall function of the manufacturing system is carried out by the objects of the

manufacturing system, the relationship between the objects, the rules contained in the simulation model and the message-based communication. The response of an object after receiving a message depends not only on the type of the message, but also on the current state of the object. Therefore, in order to better describe the complex behavior of the object, the state machine is applied to the behavior model of the object.

#### 4. Mathematical model interacts with 3D model data

The general hierarchical dimension is also the spatial dimension of integrated enterprise or factory modeling architecture. Compared with the view dimension, the general hierarchical dimension is a horizontal structure, which can be divided into general model layer, reference model layer and application model layer. Integrated enterprise modeling method attaches great importance to the establishment and maintenance of reference model, which is based on the study of a large number of engineering application cases, the analysis of many enterprises, and the extraction of their general characteristics. The main purpose of workflow management is to realize workflows in various situations, such as document approval, production process of a product, delivery and warehousing. However, their treatment processes are all described.

In general, virtual scenes and virtual instrument objects take their whole picture as the background image, and each dynamic part is embedded in the corresponding place of the background image as its sub-objects, and its dynamic model responds to various events to dynamically refresh, simulate operations, display, etc., thus constructing an overall image model. After receiving the user's actions, the image model will first simulate the corresponding actions, then send the simulation results to the mathematical model, and then the mathematical model will calculate the simulation results, and finally send them to the image model. The assembly level of geometric objects is composed of more than two levels, and each level can be composed of several modules, which can not only move together as a whole, but also move independently under certain restrictions.

The drawing time of 3D display varies with the hardware environment, so it can't be guaranteed to match the overall step length of the established mathematical model. In the calculation process, due to improper selection of integration step size, the image will be delayed and the moving object will be stagnant. In order to solve the above problems, this project plans to adopt a double-layer model structure, taking a certain time as the integration step, based on the physical model, based on the 3D drawing cycle, and based on the 3D drawing cycle, to realize the transformation and display of displacement. On this basis, C++ is used to interact with Virtools, and the velocity parameters are imported into Virtools, thus completing the dynamic generation of 3D models. The transmission process is shown in Figure 3:

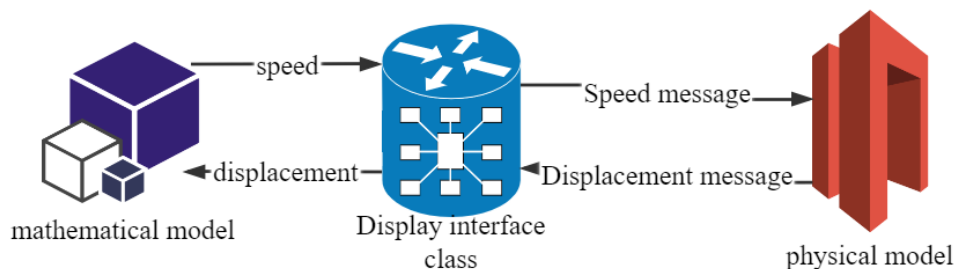


Figure 3 Mathematical model and 3D model data transfer

Through the analysis of the positional relationship between the model of each component and the plan of the whole factory, it is finally integrated into the VR platform to realize the 3D interactive roaming display. Because the spatial relationship between models has been established, it can be imported into VR only by proper format conversion.

In VR system, because the system requires the file format to be IVE, it is necessary to convert all kinds of FLT formats uniformly. After all the models of workshops, office facilities, restaurants and debugging units are converted into IVE files, the model database and dynamic scheduling database

are imported into the VR platform. In VR, there are no "import" and "open" functions, and all model attributes are carried out in the corresponding database.

## 5. Conclusions

The implementation of digital factory will be a long-term process. With the development of enterprises, it will be deepened, infiltrated and finally integrated through the use of virtual factory technology and digital technology in actual production systems. In the process of digital production, the integrated enterprise model is adopted as the reference model. Virtual machine machining system mainly simulates the machining process with virtual machine tool as the main body, and it is necessary to establish control system module, machine tool motion simulation module, machining process module and so on, and combine them organically. Through the establishment of workflow process model, product, resource, organization, function and information model are integrated, and workflow view is established to unify the expression of view, so as to reduce the losses caused to enterprises due to the continuous transformation of models and information loss. On this basis, a fast and intuitive simulation method is proposed, and a set of object-oriented 3D modeling software is developed by using VC VOpenGL.

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