

VRML-based Application in Chemical Engineering Virtual Experiment

Liu Dong and Li Yiming

College of Physics & Electronic Information Engineering, Wenzhou University, Wenzhou, China
ytdxgd041@163.com, ymli@wzu.edu.cn

Abstract. In this paper, we choose Packed-type Distillation Column experiment to construct the virtual experiment. First, we set up three-dimensional geometric model for the Packed-type Distillation Column equipment by using 3ds Max. Then, we optimize the corresponding VRML files and minimize the size of VRML files. Finally, we use of VRML technology to create the virtual course of the virtual experiment and write scripts to interact with the learner. The experimental results show that the virtual Chemical Engineering experiments have a good immersive and interactive.

Keywords- Virtual Reality; VRML; Virtual Experiment

1. Introduction

Virtual Reality (referred to as VR) technology emerged in the early 1990s. The rise of the technology provide a new description method for scientific and engineering. The technical content and artistic charm of Virtual Reality inspire people to creation more and more interactive application. Virtual Reality integrates computer hardware and software resources together, put the elements of real world to the virtual environment, people would feel like in the real world through the vision audition and interactive provided by the virtual world.

In traditional teaching conditions, students experiment has always been a relatively weak point. Limited by the lack of laboratory equipments, not every student can do the experiment by himself. This is worse in Chemical Engineering experiments. Because unlike the normal chemistry experiments, the Chemical Engineering experiments have a significant engineering feature, such as large-scale, the devices are larger, close to industrial practice etc. In the College of Chemistry and Materials Engineering of Wenzhou University, there is only one set of Packed-type Distillation Column equipment, so the most of students have no chance to do the experiment by themselves. The students have to observe the plane image in the textbook in order to understand the principle of the experiment. Sometimes they use the two-dimensional teaching software to learn how to operate experiment, the software usually made by Flash or Authorware But the two-dimensional teaching software is not a good way to absence the phenomenon of the experiment [1]. When learners roaming in the virtual lab environment, the realistic, vivid, easy-to-interactive features can make the learner interested and involved in the experiment. Learners can watch the experiment phenomenon from many angles [2].

VRML (Virtual Reality Modeling Language) is a standard file format for representing 3-dimensional interactive vector graphics, designed particularly for the World Wide Web. It has been superseded by X3D. Users can use software that support VRML standard to create a VRML model file.

In this paper, we construct the Packed-type Distillation Column model and the phenomenon of the experiment. By click the virtual valves with the mouse you will watch the process of the experiment. The learner can manipulate the virtual laboratory equipment and learn the principle of the experiment. This is an

improvement of traditional experimental teaching, allow students to better understand the principle of the experiment. The virtual experiment breaks the time and space limit of experimental operation.

The remainder of this paper is organized as follow. The second section describes the VRML technology, in the third part describes how to use modeling software to construct the virtual experiment model, and then use VRML technology to simulation of the real experiment response. In the final of this paper, we conclude of advantage and disadvantage of the virtual experiment.

2. The Vrml Technologies

VRML is the only Web-based virtual reality modeling language of international standards. The software like 3ds Max, Maya, SketchUp and other software supported the VRML standards. Use above software you can construct and import VRML files easily. VRML is an open web-based international standard, it has strong environment adaptability and scalability features. The VRML scenes can be run on Windows, MAC, UNIX and other operating systems, and could adapt to a single machine, LAN, WAN, Web environments. At the same time VRML language allow developers integrating the VRML scenes with existing popular advanced technology, which can greatly extended VRML virtual environment performance.

The VRML scene has no size limitation. Expansion and maintenance of the scene is very convenient. A model of VRML file can be distributed across network.

Establishment of three dimensional virtual reality environments, the VRML provides an international standard for the Web. It references, integrated in the method and benefits of existing system of three dimensional scene, defines the most common application of three dimensional concept, such as shape, material, texture, light, viewpoint, background, fog and all the things for the establishment of three dimensional virtual world.

The dynamic VRML scene is rendered in real time; this is the important different point to normal three-dimensional animation. When you are roaming in the virtual world which constructed by VRML in any direction and speed, the browser is always in the rendering speed of 30 frames per second in real time. This speed make you almost do not feel the existence of the rendering process, like a walk in the real world. Interaction in VRML scene is also very rich in content and form, for example, VRML97/2.0 specification provides collision and sensor, enables model in the scene can “perception” to the user’s actions, and then route these perception information passed to the script for computing, script program will be processed through the routing and delivery of the data to the appropriate objects, so that these objects have corresponding actions. These real-time interactive features allow users to be aware at the response of user’s action any time, so as to achieve the effect of virtual reality.

In order to enhance the realism of virtual three dimensional environments, VRML support of images, sound, animations and other multimedia file formats reference. By using “executable code” technology, effectively overcoming network bandwidth bottleneck, making VRML in low-speed bandwidth networks can also implement. As with HTML, VRML describe virtual scene and link by text. The information describes by text transmission on the network quickly than the graphic, but for the browser, the contents of the text are executable code. In this way, dynamic scene generation and interaction of complex tasks are excused by the local machine, thus reducing the network load. So when you browse the virtual scene, it is rely on the computation and graphics performance of the local machine, independent of the network.

VRML as a descriptive language does not include event handling method, but it can achieve the effect by through the support Web-standard embedded or referenced in other programming languages, so as to achieve its “programming” features. VRML embedded or referenced for these programs is through script nodes, supported languages include Java, JavaScript and vmlscript. The language of vmlscript is based on ECMAScript. VRML support these languages because of their very broad application on the Internet. Its own existing open standards, easy to implement integration of VRML and other Web technologies.

The basic method to create all objects in the virtual world with VRML is to use the node. VRML97/2.0 specification provides more than 50 kinds of standard node types, also allowing user define a new node type and its properties on their own.

3. The Implement of Packed-Type Distillation Column Virtual Experiment

The experiment is based on the course of Chemical Engineering in the College of Chemistry and Materials Engineering of Wenzhou University. The way separation of mixed liquid is often used distillation method, the principle which use of is different liquid have different boiling point. The device is called by distillation columns. This experiment uses the packed-type distillation column separation of alcohol and water. The figure of this experimental device is shown in Figure 1.

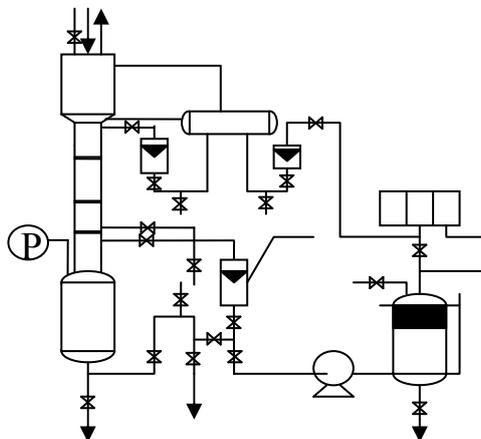


Figure 1. Diagram of the packed-type distillation column device

3.1. The Real Experiment

The real experiment consists of eight steps:

- 1) Preparation five percent of alcohol solution, by charging pump implantation of distillation still up to the level of liquid indicator.
- 2) Preparation 15~20 percent alcohol solution in the feeding groove.
- 3) Switch on the power, adjust the voltage to 220V, heating the liquid solution. Then open cold water valve, careful observe the activities of vapor and liquid. Control the temperature of heating.
- 4) Total reflux operation and control of evaporation, at this time, the temperature of sensitive plate should be at about 80 degrees.
- 5) Open pump, control flux while feeding in the alcohol solution, partially efflux operation.
- 6) In order to meets reflux requirement, so in the reflux drum, the line of products is higher than reflux line 15mm. Turn down the quantity of reflux, control the reflux ratio, meet the product requirements of concentration.
- 7) Control the amount of the discharge; make the liquid level remain the same attitude.
- 8) Measured the concentration of the sample.

3.2. The Virtual Experiment

The design and implementation of the experiment mainly includes two aspects as follows: First, create three-dimensional geometric model for Packed-type Distillation Columns, then construct the behavioral model for the virtual experiment and write the script program to implantation the interactive between learner and virtual experiment.

3.3. The Construction and Optimization of the Packed-type Distillation Columns Model

In the various popular modeling tools, 3ds Max is the best software in support VRML. 3ds Max have an excellent performance in realization of VRML geometry, material, texture appearance, background lighting and many other VRML scene features. Therefore, in this experiment, the 3ds Max is choose as the core tools to make VRML model.

3ds Max have special tools to create VRML97 special object. The VRML97 helper is an important feature of 3ds Max. When you complete the basic model in 3ds Max, you can use this tool to add supplementary

VRML97 special objects in 3ds Max models, such as anchor, AudioClip, background, and billboard etc. Finally, you complete all objects in the scene with 3ds Max, you can export the VRML97 file through call the VRML97 exporter.

Because the total capacities of the VRML file size have a great impact for the virtual scene interactive performance, so when the content is complex or the scenes in VRML scene is large, it is need to optimization some models to meet the most basic interactive virtual environment performance requirements. In order to make the file which exported by 3ds Max is small, it is necessary to control the size of the file in every aspect of modeling. The following are the methods we adopt to reduce the file size.

Using simple geometric forms (such as standard basic objects) to splicing complex model, this can make the VRML exporter using box, cone, cylinder and sphere to describing complex models, so as to effectively reduce the amount of file codes.

Reduce the segment value. Many objects in 3ds Max model have a segment value. The segment value can be used to control the detail of shape precision. The default segment value tends to be higher than needed in some model objects created in 3ds Max. You should reduce the default segment value.

Use instance/reference copy method to create various mesh modeling (mesh, poly and patch). The VRML97 exporter will use DEF, USE keywords as possible in the domain of geometry. It can reduce the repeat codes.

Use Boolean operations to make the model usually bring rapid expansion of the file data, so it is used only if necessary. If apportion of a model must be processed using Boolean operation, the better way is isolate this part from the overall modeling. When Boolean operation is done, you can delete the excess surface by editmesh command.

When the VRML scene content (including interactive programming design) completed, its file size usually have a certain, even a greater abatement of space, we can also using vrmlpad or other text-edit tools to clean the no necessary code [3].

In the modeling process, although we use instance or reference method to copy model, the VRML97 exporter refer to the copy model with the keyword "USE". But it is not approach the best effect in reduce the size of file by this way. The reason is that: the object referenced by keyword "USE" is not a complete model, but limited to very low-level in the VRML model structure, such as in the geometry field of the shape node. Thus, in the appearance of the shape mode fields and the outer shape node in the parent node, large block of codes are not included in the same node use within the scope of the referenced object. If using copy method to make a lot models, then it is necessary to optimize the file by code edit method, and the key tool to do this is text editor with multiple line find and replace.

When completed the programming design of interaction in the scene and optimization is done by the above methods. There is still have some useless junk code in the VRML files, such as extra spaces, indentation, useless DEF node definitions, node domain specified with the default value, comment text which is no longer needed. For these invalid codes, use vrmlpad macro commands can easy clean them.

Finally, the original model of the virtual experiment is shown in figure 2:

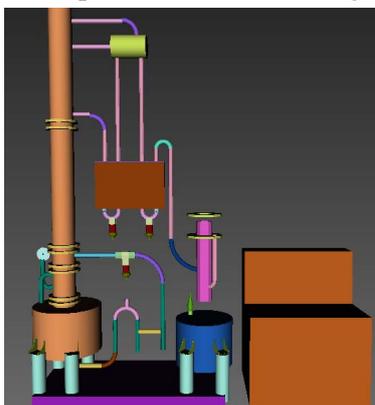


Figure 2. the original model of the virtual experiment

3.4. The Interaction of Virtual Experiment

In the virtual reality experiments, interactive is the most important features. Interactive means when user controls the virtual objects in virtual world, the objects can respond to user in real time. In VRML scene, the most basic interaction is that users can move through the pointing device to substitute and the virtual environment to transform perspective to respond to the substitute's move [4]. The interaction mainly discussed in this virtual experiment is between learner and the virtual objects in virtual scene. When learner clicks the switches or valves in the virtual scene, can trigger certain behavior or change the states of the virtual object. To achieve the effect, some special elements of VRML must be attached to virtual space, mainly including: space sensor, script program and route connection.

Learner interaction with the virtual space is conducted by point input device. With the space sensor, the virtual scene can detect the learner's operation, and then the detected behaviors can be used to trigger a virtual object to respond the learner's actions. VRML provides a total of 6 kinds of space sensors, including touch sensor, proximity sensor, visibility sensor, plane sensor, cylinder sensor and sphere sensor. In addition to the above sensors, the collision node and anchor node can also play a similar role to the sensor in some cases.

Script programs generally apply to a higher level of interactions. VRML script can be understood as event handler for the VRML scene, its role is to obtain data from the sensor, and then through a certain program, output the converted object. VRML allows the user use vrmlscript, JavaScript or java to write script program [5].

The script node added to the virtual world is the engine that makes communication with the scene possible. Although VRML support we use vrmlscript, JavaScript, Java language to write script program. The vrmlscript language is the best choose have two reasons. First, VRML browsers seem to support vrmlscript better and more consistently. Second, vrmlscript is simply a text file that is interpreted. dynamic The same process in Java would require writing out and compiling a class file before sending it to the client.

As with VRML animation, to create interactive effects also need to use a routed connection. Sensor sends out data from space, you first need to transfer the data to script program through routing, calculations by the script program and then transfer the output to the virtual object by routing.

At the end of the experiment, when the record of experimental data is finished, we shall set the system back to its initial state in order to the next experiment with this Packed-type Distillation Column.

4. Conclusion

This paper describes the characteristics of VRML, focuses on the implantation of Chemical Engineering experiment by using VRML technologies. When VRML technology is apply to virtual experiments, it could make the students feel that they are personally on the scene. In our future research, we will create more accurate model and intend to write script programs that correspond to real experiment. UI (user interface) of the system is not friendly enough to the learner. The next work is improve the UI, and give some advices to the learner when they operation the virtual experiment.

5. References

- [1] Li Yongfeng. Virtual Experimental System of Machinery Foundation Based on VRML [J]. Research and Exploration in Laboratory, 28(9): pp: 69-71. 2009.
- [2] Guo Yi, Chen Dailin, Jiang Li. A 3D Architectural Modeling and Decoration Design System Based on Virtual Reality [J]. Computer Simulation, 25(11), pp: 242-246. 2008.
- [3] Weiqun Luo, Chungui Liu, Erping Zhao, Jianguo Wang, Hongen Dang. The Implementation of the VRML-Based Digital Circuit Virtual Experiment [J]. Wireless Communications Networking and Mobile Computing (WiCOM), 2010 6th International Conference on, pp 1-4.
- [4] Sun Qi, Liu Ying-chun, Xu Chun-xia. Implementation of virtual scene roaming based on VRML [J]. Computer Engineering and Design, vol 29 no.14, pp: 3748-3751. 2008.
- [5] Li Hui-xiang, Chen Zhi-gang, Zheng Yi, Li Xin, Li Nan. Walkthrough Technology of Rocket Artillery Dummy Structure Based on VRML [J]. Ordnance Industry Automation, vol 29, pp: 27-30. 2010.