软件学报

分布式虚拟环境综述

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Abstract

Information sharing and interaction in distributed virtual environments are performed by users or multiple virtual environments through networks. This paper, based on the authors' research work, discusses the development, characteristics, models, and structures of the distributed virtual environment and the key technologies. The problems and further development directions are also discussed.

Key Words

Virtual Reality, Distributed Virtual Environment, Scalability, Network Communication, Virtual Reality Modeling Language

中图分类号

RSE'E

With the rapid development of computer and communication technology, people are moving toward an information-oriented society. The research results and development trends indicate that two technologies will have a significant impact on the future information society and eventually change our life and work mode. These are Virtual Reality (VR) and the Internet. The Virtual Environment (VE) is the combination of these two technologies. It is a distributed simulation environment that can be accessed through a network. People can enter the VE and interact with the virtual environment.

DVE systems can be traced back to the early 1980s. In recent years, with the rapid development of network technology, DVE systems have received more attention. The US Department of Defense (DoD) provided typical support to DVE research and development. One such project was the "Distributed Interactive Simulation" (DIS) project, which was later standardized as the DVE protocol. Other successful applications of DVE include network flight simulation and network game simulation. The DVE system should have the following characteristics:

1. Shared virtual work space
2. Realistic behavior of pseudo entities
3. Real-time interaction
4. Shared clock
5. Multiple users communicating in different ways
6. Resources information sharing and allowing users to naturally manipulate objects in the environment.

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1.1 DVE

DVE is a system that consists of several basic components such as graphical displays, interactive control devices, and a processing system and data networks. The system is a distributed system and its requirements can be attributed to two aspects: the system's own requirements and the requirements of a distributed system. Table 1 shows the requirements of DVE systems.

<table>
<thead>
<tr>
<th>Requirements of VR</th>
<th>Requirements of distributed systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rendering in various forms (graphics, audio, text)</td>
<td>Naming service</td>
</tr>
<tr>
<td>Low latency, high updating rate</td>
<td>Service-Request matching</td>
</tr>
<tr>
<td>Capability to process different input devices</td>
<td>Resource finding and location</td>
</tr>
<tr>
<td>Collision detection</td>
<td>Distributed storage of data</td>
</tr>
<tr>
<td>Navigation and viewpoint controlling</td>
<td>Dynamic load balancing</td>
</tr>
<tr>
<td>Construction of virtual world</td>
<td>Security management</td>
</tr>
<tr>
<td>Management of scene database</td>
<td>Multicast</td>
</tr>
<tr>
<td>Complex behavior modeling</td>
<td>Support for continuous media</td>
</tr>
</tbody>
</table>

1.2 Typical tools or systems

DVE is the first commercial product that runs in a distributed environment, developed by the company. In 1999, the company was acquired by the company, and a comprehensive engineering visualization product was launched. This software supports Tr and other virtual reality platforms, and includes a module for distributed virtual modeling on the Internet.

Other tools include:

- DVENET: [15-16]
- DIVER: [17]
- YHYRP: [17]
- Arai: [18]
- Maxfield: [19]
- Internet: [20]

1.3 Summary

In recent years, due to the widespread use of applications, some tools have emerged that are specifically designed for these applications, allowing users from around the world to collaborate in real-time.
表2 在典型DVE系统中分布特性比较

<table>
<thead>
<tr>
<th>Systems</th>
<th>dVS</th>
<th>MR</th>
<th>DIVE</th>
<th>NPSNET</th>
<th>AVIARY</th>
<th>DVENET</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sharing model</td>
<td>Shared DB</td>
<td>Shared DS</td>
<td>Shared DB</td>
<td>DIS</td>
<td>Object oriented</td>
<td>DIS</td>
</tr>
<tr>
<td>Replication</td>
<td>Partial</td>
<td>2 copies</td>
<td>Whole</td>
<td>Whole</td>
<td>Whole</td>
<td>Whole</td>
</tr>
<tr>
<td>Communication scheme</td>
<td>C/S</td>
<td>Master/Slave and Peer-to-Peer</td>
<td>Peer-to-Peer</td>
<td>Peer-to-Peer</td>
<td>Peer-to-Peer and message passing</td>
<td>C/S and broadcast</td>
</tr>
<tr>
<td>Distributed computation</td>
<td>No support</td>
<td>support</td>
<td>No support</td>
<td>No support</td>
<td>Support</td>
<td>Support</td>
</tr>
<tr>
<td>Parallel granularity</td>
<td>Coarse</td>
<td>Coarse</td>
<td>Coarse</td>
<td>Coarse</td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Parallel unit</td>
<td>Process</td>
<td>Process</td>
<td>Process</td>
<td>Player</td>
<td>Object</td>
<td>Object</td>
</tr>
<tr>
<td>Load balancing</td>
<td>No support</td>
<td>No support</td>
<td>No support</td>
<td>No support</td>
<td>Support</td>
<td>N/A</td>
</tr>
<tr>
<td>Network environment</td>
<td>Heterogeneous</td>
<td>Heterogeneous</td>
<td>Heterogeneous</td>
<td>Heterogeneous</td>
<td>Heterogeneous</td>
<td>Heterogeneous</td>
</tr>
</tbody>
</table>

1. 1
2. 2

2.1

DVE是一个分布式面向对象的系统。它支持多个用户/虚拟世界和应用。

2.2

2.2.1

DS (decoupled simulation model)
VR system software architecture based on DS model. Fig. 2 Modifier-Presentation-Sensor-Controller model.

3 DVE

DVE with a distributed software architecture is designed based on the DS model. The DVE framework is composed of six parts: Computation, Geometry model, Presentation, Interaction, Controller, and Modifier. The software is designed with Java/VRML and Plug-in mechanism to support distributed applications. The DVE framework is scalable and adaptable to various requirements. It includes VR, MR, CSCW, and Plug-in tools.

3.1 DVE

(1) d e  f g h i j k

VR system software architecture based on DS model. Fig. 2 Modifier-Presentation-Sensor-Controller model.

2.2 MPSC

MPSC (Modifier-Presenter-Sensor-Controller) is a distributed software architecture designed for VR systems. It is based on the DS model. The MPSC framework includes six parts: Intelligent agent, Computation, Geometry model, Presentation, Interaction, and User. The software is designed with Java/VRML and Plug-in mechanism to support distributed applications. The DVE framework is scalable and adaptable to various requirements. It includes VR, MR, CSCW, and Plug-in tools.

2.2.2 MPSC

MPSC (Modifier-Presenter-Sensor-Controller) is a distributed software architecture designed for VR systems. It is based on the DS model. The MPSC framework includes six parts: Intelligent agent, Computation, Geometry model, Presentation, Interaction, and User. The software is designed with Java/VRML and Plug-in mechanism to support distributed applications. The DVE framework is scalable and adaptable to various requirements. It includes VR, MR, CSCW, and Plug-in tools.
网络通信和网络协议

与系统的高交互性和实时性相比，网络通信的带宽（延时就成为系统的主要限制）要支持快速实时的网络通信，主要有两方面的问题。一方面是当系统的规模变大时，多个之间的通信量会激增。在中，大量分布于不同地点的计算机通过网络连接在一起，要使各工作站保持连续状态是一个颇具挑战性的课题之一。另一方面是几何模型数据的实时传输问题。这里可应用的技术包括多分辨率模型传输（几何数据快速缓存及预取）。另外，一些传统的网络协议并不能满足的需求，必须研究新的面向的网络协议。现有的一个典型例子是虚拟现实传输协议，简称VRTP。

快速环境建模和实时图形绘制的快速建模问题也是一项关键技术。传统的基于几何的建模方法有其固有的缺点：速度慢、真实感差。现在，基于图像和几何的混合造型方法已得到较为广泛的使用。另外一个重要问题是空间信息的有效组织与展示。在构造过程中需要了解对应于不同个体和任务的信息的不同视点，同时需要建立通过多个视点显示大量信息的机制。实时图形绘制是的又一项关键技术。用于满足用户在虚拟环境中的沉浸感，在中，这个问题变得更复杂。可以考虑使用限时计算（多细节层次模型、智能化视区裁剪、场景预处理、基于图像的绘制等技术）来保证图形的实时绘制。需进一步研究的问题是异构性。分布式环境决定了系统必须支持异构性。系统中的多个用户所用的计算机（软件环境、交互手段）不尽相同，另外，用于连接整个环境的网络也可能有多种。然而现有的大多数系统所支持的计算机种类是有限的。规模可扩充性意味着一个系统在其用户逐渐增加时，不必对系统作重大修改就可依然保持其运行效率。阻碍规模可扩充性的两个主要因素是带宽瓶颈和计算瓶颈。只有很少的系统考虑了这个问题，例如采用空间逻辑划分以及网络支持的通信来降低网络传输信息量，同时还利用算法来降低网络延迟。我们通过研究发现，在中，空间逻辑划分的基本单元--六边形区域不够灵活。若要有效地降低通信量，必须综合利用多种技术，包括视区裁剪（多分辨率模型、运动预测技术等）。

动态可扩展性通常由分布很广的多个相连的计算机组成，用户的资源和运行环境可能经常发生变化，这就要求系统能够动态地调整自己的功能，而不必改变系统本身。另外，系统应能提供服务资源的匹配机制，但现有系统很少考虑用户的动态注册（资源定位和任务资源匹配问题）。

行为真实感由于受现有计算能力和网络通信能力的影响，使得很多现有中的场景相对简单，给用户的真实感不强。另外，现有的大多数系统仅支持简单的行为建模，从而也对真实感产生影响。虚拟环境软件结构既要支持实时交互性，又要针对不同的行为特性支持足够的行为真实感。

安全性设施能够用于证实在特定访问限制条件下是否允许所请求的动作，或用于确认系统中代表人的对象或一般对象的身份。目前所有系统都不提供安全性控制服务。

结束语由于系统涉及到多方面的知识并使用多种不同的技术，必须把多种传统类型的软件集成到单个应用系统中，既是一个分布式系统，又是一个图形应用系统，还是一个交互式应用系统。要开发一个成功的系统需要考虑多种因素，有限的网络带宽（异构性！硬件异构！软件异构！网络异构！分布交互性！失败管理！规模可扩展性及可配置性）的进一步发展方向包括支持协同工作，位于不同虚拟环境中的用户进行协同设计（协同医疗会议、协同可视化，形成协同虚拟）。
(2) Internet ATM. Internet ATM has achieved a great deal in this aspect, especially in the military field. ATM is a good candidate for CAVE DVE.

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(5) DVE VR. VR: Research, Development and Application, 1996,2(1):155~175

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Distributed Virtual Environment: An Overview

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Abstract In DVE (distributed virtual environment), multiple users or environments located in different places connect to each other by network. Users can share information and perform interaction. Based on their studies, the authors give an overview of the research work done in the field of DVE in this paper, including its origin, requirements and features, model and architecture, typical systems and key techniques. Finally, some existing problems which need the further study and the further development of DVE are discussed.

Key words Virtual reality, distributed virtual environment, scalability, network communication, VRML, (virtual reality modeling language).