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COVASE: COLLABORATIVE VISUALIZATION FOR CONSTRUCTIVIST LEARNING

Abstract. The paper specifies CoVASE, a software for teachers to create and view networked learning environments (VE). Students carry out virtual experiments in CoVASE, at the same time and different places. They use the same tools and work on the same scientific problems as researchers do. Teachers create a motivating, demanding, and authentic interaction between learners and real-world problems, a premise for constructivist learning (CL). CoVASE generates and displays the result of a numerical simulation in parallel of its progress on distributed 3D graphic viewers, steered by users in real time. VEs mediate communication between users, deictic elements, and display. Researchers and students have evaluated the predecessors of CoVASE with good results. A field study is planned for 2003.

1. INTRODUCTION AND OVERVIEW OF COVASE

The paper specifies a framework for scientific 3D visualization and collaborative work in the natural sciences and engineering. Completed examples are Finite Element Analysis, Computational Fluid Dynamics, and Volume Visualization. Teachers compose 3D ‘learning worlds’ where students carry out tasks. Instructors can evaluate new theories of learning, and software designers can adapt our design. Our goals are:

- Develop a versatile visualization tool that scientists and students use.
- Evaluate if immersion, i.e. to deepen in a VE, positively affects learning.
- Identify VE components that foster collaborative, self-directed learning.

Our objectives in the scope of the VASE 3 project are as follows:

- Let users study with CoVASE (Figure 1), and identify system weaknesses.
- Examine how students perform with stereoscopic and monoscopic viewing.
- Integrate CSCW components in the VE, examine which is used why.

CoVASE is a framework for software to mediate among humans, computers, and between them. We use simulated experiments because their visualization adapts to different views, they externalize patterns in processes that are difficult, expensive, or risky when carried out in reality, and interactions can be repeated and recorded. Virtual Reality hardware will increase perceptual authenticity, draw on tacit knowledge of operating entities, and preserve cues for perceiving multi-sensual stimuli.

2. COVASE, DIDACTIC CONCEPT, AND SOFTWARE DESIGN

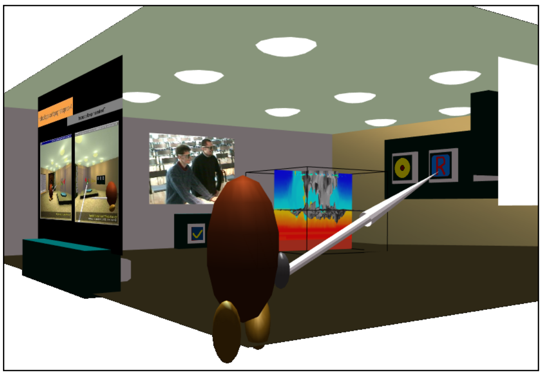


Figure 1. A synthetic 'Collaboratory' in CoVASE (Andersson, 2002; Jensen, Olbrich, Pralle, & Raasch, 2002).

Figure 1 shows an example, created and used with CoVASE. In the center is a 3D model of an oceanic convection and a slice to display temperature, where blue denotes low and red high temperature. Completed graphical interactive elements are: button, pointer, avatar, slide, and video wall (from right to left). Mutually aware users enter and use the VE together from their networked computers with mouse and keyboard. CoVASE is novel because it visualizes and controls *complex* results of computer simulations in custom interfaces on remote computers. Constructivist learning (CL) with expert simulations is possible (Duffy & Jonassen, 1992).

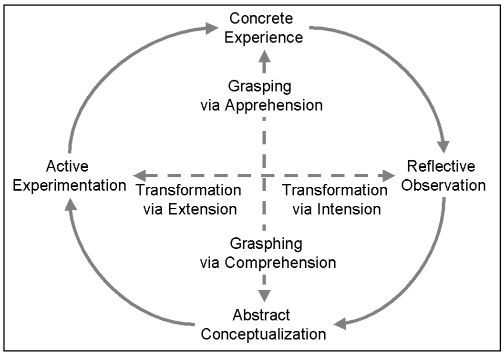


Figure 2. Experiential Learning Cycle, adapted from Kolb (2001).

CoVASE is valuable because it (i) allows users structured and easy reuse of material and (ii) remedies the lack of tools that support CL to facilitate students' *autonomous* learning in groups, see Figure 2 (Kolb, 2001). CL helps groups to perceive their progress in building knowledge among subjects, and to synthesize viewpoints, see Scardamalia & Bereiter (1992). CL tools foster *self-directed learning in groups* with use of *expert tools and data* that aid teachers to direct students. But why visualize? McCormick, DeFanti, and Brown (1987) motivate the use of computer graphics for creating visual metaphors to describe data related to processes and entities. Visualization eases human perception. Wood, Wright, and Brodlie (1997) discuss collaborative visualization. They note that problem solving by way of visualization is predominantly group-oriented, consistent with CL theory.

CoVASE enforces and structures reuse of VEs and visualizations. It must be customized before use. CoVASE implements CSCW at different places, at the same and different time, compare the time/space matrix in Baecker (1993, p. 11, Fig. 2). CoVASE provides a unique combination of features: synchronous communication via gestures by pointers, movement of avatars, video conferencing; asynchronous communication by way of recording and replaying interaction (in progress); composition of VEs from predefined software; animated visualization of complex remote simulations (in progress); extensibility. Figure 3 shows related systems.

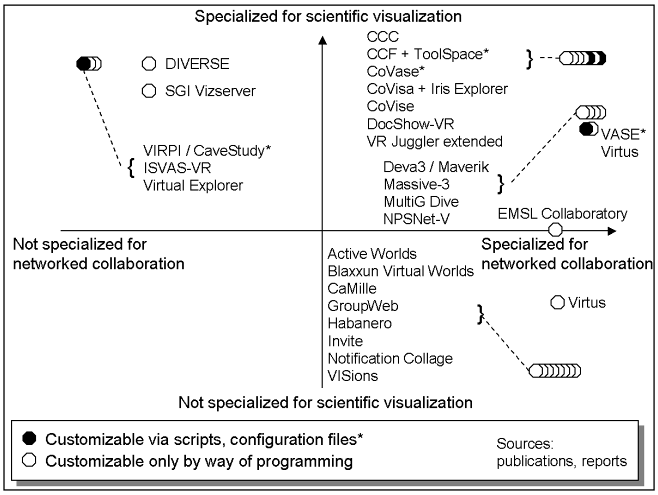
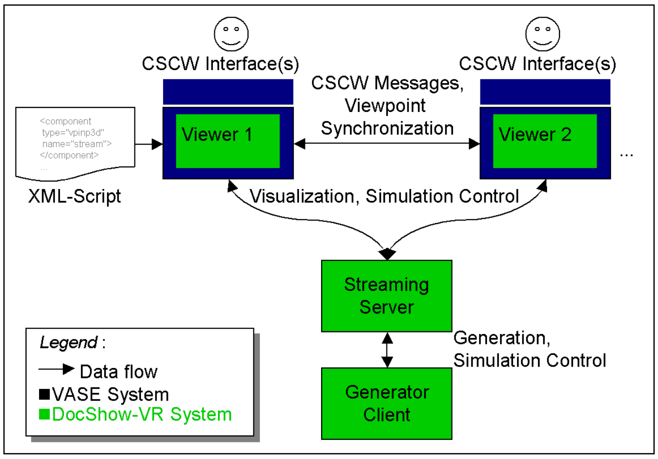


Figure 3. Classification of CSC and visualization toolkits.*

From bottom-right in clockwise order we have classified representative (i) systems that only enforce CSCW and socialization in networked VEs, (ii) unrelated systems (iii) scientific visualization software without CSCW, and (iv) scientific visualization systems for CSCW and toolkits to manage network-distributed VEs. The latter are most similar to CoVASE but they provide not as many specialized visualization methods as we do, do not perform well for the visualization and control of large volumes of time-variant data, do not record events and replay them, or support more users than we do at the cost of making the creation of VEs difficult and error-prone, (Wood, Wright, & Brodlie, 1997; Benford, Greenhalgh, Reynard, Brown, & Koleva, 1998). An exception is for example Watson (2001), but he does not specify results for the application in education, in contrast to Edelson, Pea, and Gomez (1994). Their system, CoVIS, uses Web software that does not control simulations in an interactive way, but like ours supports scaffolding, i.e. teachers that coach students online.

Users cannot participate regularly during development of CoVASE, and their use of the system is not predetermined. Use cases track requirements, they are semi-formal interactions between users and software. The paper reports one. The validity of the use cases will be tested in a field study with students and teachers during lectures and computer laboratory sessions. Details will be specified 2003.



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<component
 type="vpinp3d"
 name="stream">
</component>
...
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Figure 4. CoVASE diagram shows: software layers, communication paths.

Figure 4 is an overview of CoVASE that combines a collaborative VE system (VASE; described in Andersson, 2002) and a networked visualization system (DocShow-VR; see Jensen, Olbrich, Pralle, and Raasch (2002)). Viewers display the same CSCW interface that an XML text file specifies. The use of XML compared to a proprietary format is advantageous for us because we plan to add descriptions of VEs, and develop a Document Type Descriptor (DTD) for our XML format. More sophisticated DTDs exist, but we aim for simplicity. The text file contains CSCW tool names and messages. Different messages are understood by different tools. For example, a button would initiate a 3D animation as follows (compare Table 1):

...<button1> DocShow-VR : play : stream </button1>...
<component type="vpinp3d" name="DocShow-VR"> </component>...

CSCW tools are Dynamic Link Libraries under MS Windows that process VASE alphanumeric messages. VASE exchanges these synchronous messages over TCP/IP to synchronize viewpoints and CSCW messages between viewers. DocShow-VR connects over TCP/IP to a simulation on a remote computer that sends 3D graphic objects to a streaming server for replication to each viewer. The server receives commands from viewers to control object display and generation.

How to use the system? A tutor publishes an XML file to specify the location of a remote simulation. She starts CoVASE with the file, and her video conferencing hardware. The VE displays video images of students. After briefing, they play and navigate the visualization by a virtual control panel, move avatars, point at, and annotate parts with 3D text by mouse and keyboard. Students send text messages to negotiate their findings, and can consult their remote supervisors.

Table 1. XML tags, compare Andersson (2002)

Tag	*Specification*
component type	Software, e.g. VE, buttons, image, avatar, video, DocShow-VR
object	Inclusion of static geometries, e.g. interior of a VE
scale, width	Graphical size
start, translate	Coordinate of position at startup
texture	Image

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