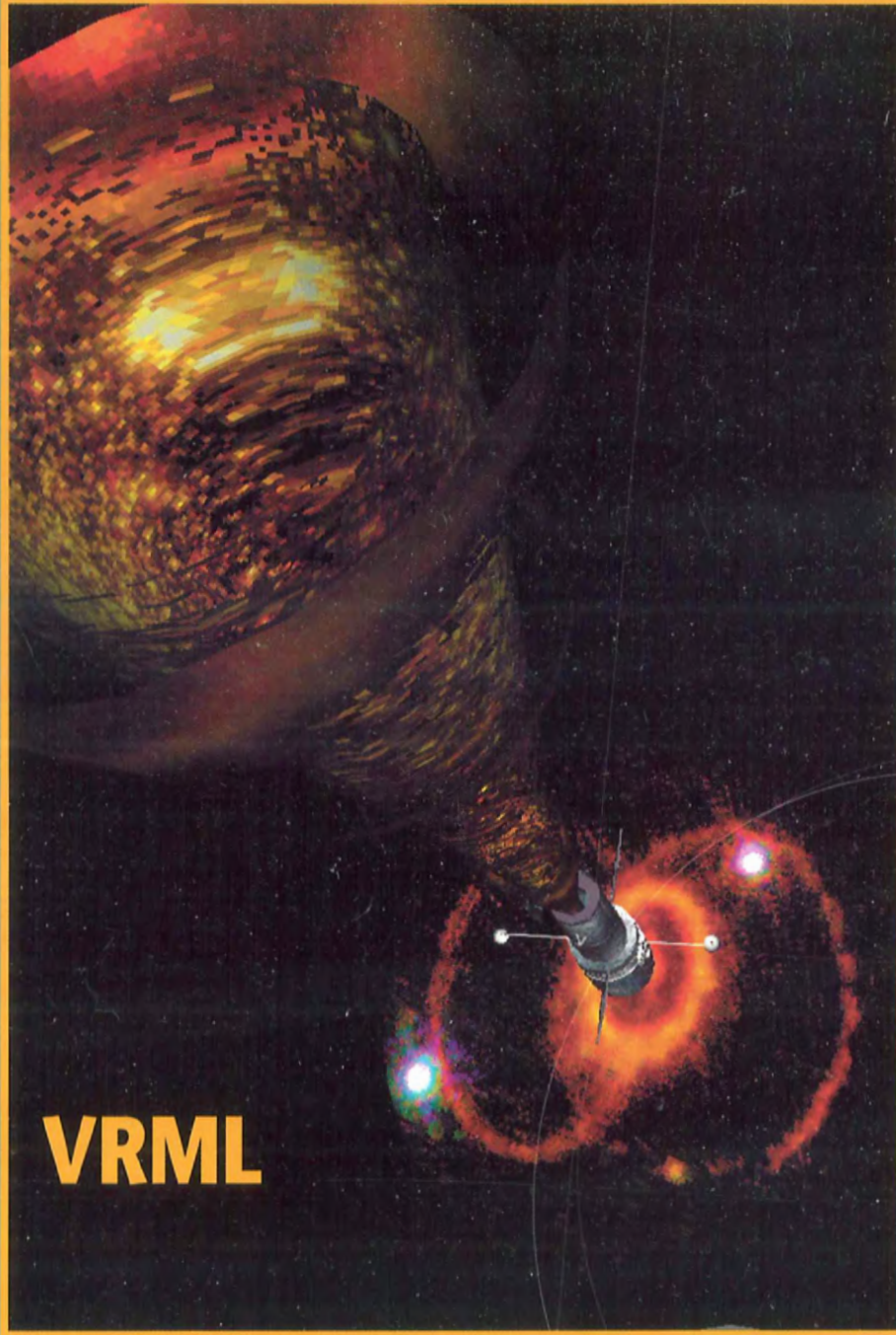


IEEE Computer Graphics

AND APPLICATIONS

<http://computer.org>

MARCH/APRIL 1999



VRML

- Public Speaking in VR
- Glassner on string Crossings

***** ALL FOR ADC 64240 00260
031999 306
LINDA HALL LIB
SERIALS DEPT
5109 CHERRY ST
KANSAS CITY MO 64110-2425

IEEE
COMPUTER
SOCIETY

Page 1 of 13

Unified Patents Exhibit 1010

**DOCKET
ALARM**

Find authenticated court documents without watermarks at docketalarm.com.

IEEE Computer Graphics AND APPLICATIONS

IEEE Computer Society
10662 Los Vaqueros Circle, PO Box 3014
Los Alamitos, CA 90720
<http://computer.org/cga>

Editor in Chief
James J. Thomas
Pacific Northwest National Laboratory
902 Battelle Boulevard
Richland, WA 99352
Jim.Thomas@pnl.gov

Submissions: Please submit seven copies of all articles to Alkenia Winston, magazine assistant, IEEE Computer Society, 10662 Los Vaqueros Circle, Los Alamitos, CA 90720. Submit proposals for special issues to Michael Rhodes, mrhodes@odsus.nj.com. All submissions are subject to editing for style, clarity, and space considerations. An author's guide is available from the Web, publications office, or by e-mail from awinston@computer.org.

Associate Editors in Chief

Michael L. Rhodes Ortho Diagnostic Systems
Turner Whitted Microsoft

Editorial Board

Frank W. Bliss EDS/GM Corp.
John C. Dill Simon Fraser University
Rae A. Earnshaw University of Bradford
José L. Encarnação Technical University of Darmstadt
Andrew Glassner Microsoft
Markus Gross ETH, Zurich
Bertram Herzog University of Michigan
Tosiyasu L. Kunii Hosei University
Carl Machover Machover Associates
Gregory M. Nielson Arizona State University
Michael J. Potel Wildcrest Associates
Theresa-Marie Rhyne Lockheed Martin
Lawrence J. Rosenblum Naval Research Laboratory
Maureen Stone StoneSoup Consulting

Managing Editor Nancy Hays

Assistant Editor Robin Baldwin

Editorial Assistant Kristine Kelly

Magazine Assistant Alkenia Winston

Art Direction Joe Daigle

Publisher Matt Loeb

Advertising Manager Patricia Garvey

Advertising Supervisor Marian Anderson

Advertising Coordinator Debbie Sims

Member/Circ. Promo Mgr. Georgann Carter

Publications Board

Benjamin Wah (Vice President),
Gul Agha (MOC chair), Jon Butler (TOC chair),
Ron Williams (IEEE Pubs Representative),
Jake Aggarwal, Alberto del Bimbo, Mike Liu, Zhiwei Xu

Magazine Operations Committee

Carl Chang (chair), William Everett (vice chair),
James H. Aylor, Jean Bacon, Washow Chou, George Cybenko,
William I. Grosky, Steve McConnell, Daniel E. O'Leary,
Ken Sakamura, Munindar P. Singh, James J. Thomas,
Yervant Zorian

Editorial: *IEEE Computer Graphics and Applications* serves both users and designers of graphics hardware, software, and systems. Its readers work in industry, business, the arts, and universities. Articles are peer-reviewed; departments are refereed. Unless otherwise stated, bylined articles and departments, as well as descriptions of products and services, reflect the author's or firm's opinion; inclusion in this publication does not necessarily constitute endorsement by the IEEE or the Computer Society.

Copyright and reprint permission: Abstracting is permitted with credit to the source. Libraries are permitted to photocopy beyond the limits of US copyright law for private use of patrons those articles that carry a code at the bottom of the first page, provided the per-copy fee indicated in the code is paid through the Copyright Clearance Center, 29 Congress St., Salem, MA 01970. Instructors are permitted to photocopy isolated articles for noncommercial classroom use without fee. For other copying, reprint, or republication permission, write to Copyrights and Permissions Department, IEEE Publications Administration, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331. All rights reserved. Copyright © 1999 by the Institute of Electrical and Electronics Engineers, Inc.

Circulation: *IEEE Computer Graphics and Applications* (ISSN 0272-1716) is published bimonthly by the IEEE Computer Society. IEEE Headquarters: Three Park Ave., 17th Floor, New York, NY 10016-5997. IEEE Computer Society Headquarters: 1730 Massachusetts Ave., Washington, DC 20036-1903. IEEE Computer Society Publications Office: 10662 Los Vaqueros Circle, PO Box 3014, Los Alamitos, CA 90720; (714) 821-8380. Annual subscription: \$34 in addition to any IEEE group or society dues. Members of other technical organizations: \$90. Nonmember subscription rates are available on request. Back issues: members, \$10; nonmembers, \$20. This journal is also available in microfiche form and on the Web.

Postmaster: Send address changes and undelivered copies to *IEEE Computer Graphics and Applications*, IEEE Computer Society, 10662 Los Vaqueros Circle, PO Box 3014, Los Alamitos, CA 90720. Periodicals postage is paid at New York, NY, and at additional mailing offices. Canadian GST #125634188. Canada Post International Publications Mail Product (Canadian Distribution) Sales Agreement #0487848. Printed in USA.

Moving?

PLEASE NOTIFY Mail to
US 4 WEEKS IEEE Computer Society
IN ADVANCE 10662 Los Vaqueros Circle
 PO Box 3014
 Los Alamitos, CA 90720

- This notice of address change will apply to all IEEE publications to which you subscribe.
- List your new address below.
- If you have a question about your subscription, place your address label here and clip this form to your letter.

ATTACH
LABEL
HERE

Name (please print) _____

New address _____

City _____

State/Country _____

ZIP _____

IEEE Computer Graphics AND APPLICATIONS

Articles

March/April 1999

Volume 19 Number 2

Published by the IEEE Computer Society

VRML

17 Guest Editor's Introduction:
Virtual Reality Modeling Language
Maureen Stone

18 Tutorial: Building Virtual Worlds
with VRML
David R. Nadeau

VRML makes it easy to create virtual worlds. This tutorial reviews VRML's syntax and features as well as its world construction and animation abilities.

30 TerraVision II: Visualizing Massive
Terrain Databases in VRML
*Martin Reddy, Yvan Leclerc, Lee Iverson,
and Nat Bletter*

To disseminate 3D maps and spatial data over the Web, the authors designed massive terrain data sets accessible through either a VRML browser or the customized TerraVision II browser.

39 Large-Scale Mine Visualization
Using VRML
Keith Russ and Andrew Wetherelt

Traditionally, mine plans and sections in 2D stored 3D information. This article shows that using VRML to model this information leads to new, interactive methods of data visualization.

45 "Bottom, Thou Art Translated":
The Making of VRML Dream
Stephen N. Matsuba and Bernie Roehl
Bringing virtual theater to the Web requires 3D graphics, efficient networking, and strong content. The authors discuss the VRML Dream Project, a real-time Internet performance.

52 Developing the VRML 97
International Standard
*George S. Carson, Richard F. Puk, and
Rikk Carey*

VRML 97 arose from a cooperative effort between the standards and VRML communities. The methodology employed applies equally well to development of future standards.

59 VRML Testing: Making VRML Worlds
Look the Same Everywhere
*Mary Brady, Alden Dima, Len Gebase,
Michael Kass, Carmelo Montanez-Rivera,
and Lynne Rosenthal*

NIST tools address problems posed by testing 3D graphics. This article explains the test development strategy and design issues in developing and delivering these testing tools.

68 A Framework for Streaming Geometry
in VRML
*André Guézic, Gabriel Taubin, Bill Horn,
and Francis Lazarus*

The authors introduce a framework for streaming geometry in VRML that eliminates the need to perform complete downloads of geometric models before starting to display them.

79 Dynamics Modeling and Culling
*Stephen Cheney, Jeffrey Ichnowski, and
David Forsyth*

The tools described permit including large numbers of complex dynamic models in a VRML world easily and efficiently while maintaining high frame rates.

<http://computer.org/cga/>

ISSN 0272-1716



Departments

4 About the Cover

Advancing 3D through VRML
on the Web

6 Projects in VR

Public Speaking in Virtual
Reality: Facing an Audience
of Avatars

10 Applications

VizSim Technology Helps
Find Oil Faster

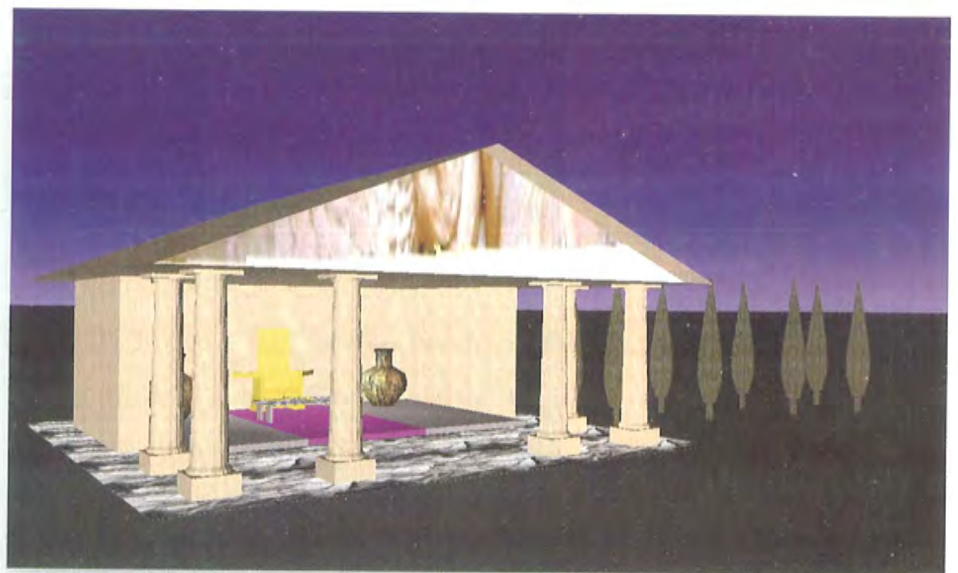
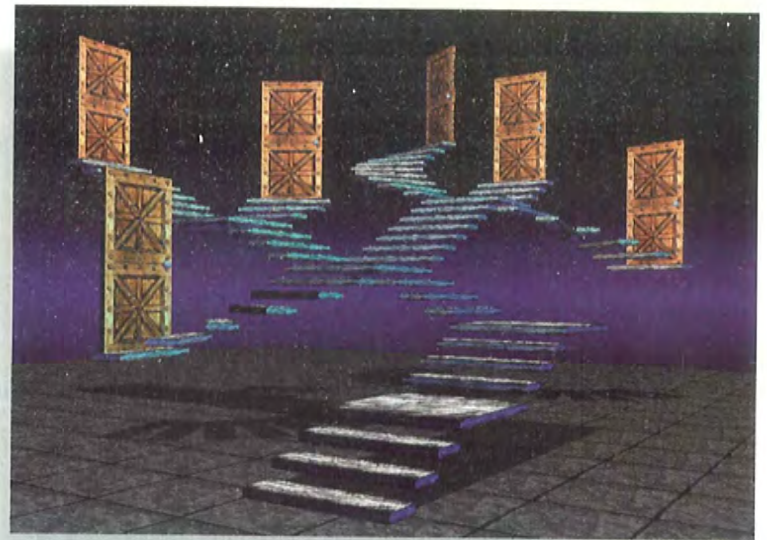
88 Andrew Glassner's Notebook

String Crossings

96 New Products

100 Advertiser/Product Index

Computer Society Information, C3
Change of Address form, p. 1



TerraVision II: Visualizing Massive Terrain Databases in VRML

To disseminate 3D maps and spatial data over the Web, we designed massive terrain data sets accessible through either a VRML browser or the customized TerraVision II browser.

Researchers have increasingly turned to Virtual Reality Modeling Language (VRML) to represent geographic information. In VRML's early days, the result was a few toy examples that did not scale well, such as coarse, single-resolution elevation grids. Today, VRML is drawing more serious interest from researchers across the spectrum, including geographers, cartographers, geologists, and computer scientists, as the sidebar "Related Work" describes. As Theresa-Marie Rhyne noted, geographic information system (GIS) and scientific visualization tools have begun to expand into each other's

domains,¹ and VRML offers cartographers and geographers the potential to disseminate 3D maps and spatial data over the World Wide Web. However, to date we have not seen useful large-scale VRML geographic databases.

Martin Reddy, Yvan Leclerc, Lee Iverson,
and Nat Bletter
SRI International

We aim to enable visualization of near photorealistic 3D models of terrain that can be on the order of hundreds of gigabytes. This might include different types of terrain imagery for particular regions, as well as site models and auxiliary information for ground features.

The following scenario indicates the capabilities required. Say a user wants to find a particular building in a particular city. Her journey begins with a 3D model of the earth viewed from space. This model is texture-mapped with satellite imagery of 100 kilometers resolution—that is, each pixel in the texture map represents a region on the planet's surface covering 100 km². To find the city, the user first rotates the earth to view the

target region in the region, higher resolution imagery, are produced until she is "flying" to one-meter resolution. rain, alternative photographs; the top of the terrain up area, 3D models the user clicks on played in a separate method, the user out the navigation an active map into landscape being v

In setting out to define four principal

- **Scalability.** Our sets. Common many millions imagery.
- **Composability.** the introduction data, including tural features, a user switch betw
- **Efficiency.** Users structures easily VRML browser c increases brows
- **Data interchange.** resentations for will let other geo using the same n

Related Work

Currently, interesting and significant work addresses the problem of representing geographic data in VRML. In the earth sciences, Kate Moore described the work of the Virtual Field Course (VFC) project,¹ which is developing software tools to familiarize students with fieldwork locations and aid data collection and analysis. The VFC project uses VRML and Java to provide interactive 2D and 3D views of geo-referenced data to enhance students' cognition of the real environment.

The US Naval Postgraduate School is currently working on a project to develop a 3D model of the Monterey Bay National Marine Sanctuary. They aim to create a VRML representation of the sanctuary based on raw bathymetry (below sea level) data for a 2.5 × 2.5 degree region of the bay. Their representation uses multiresolution techniques to deliver these large data amounts over a 28K modem connection.

Michael Abernathy and Sam Shaw described their work using VRML to visualize the course for a 197-mile relay race through the San Francisco Bay Area.² They did this using standard US Geological Survey (USGS) 7.5 arc min digital elevation models (DEMs) for the terrain geometry with geo-referenced satellite imagery draped over the terrain. Their system also used Global Positioning System (GPS) input to create a line segment showing the race's course over the VRML terrain.

References

1. K. Moore, "Interactive Virtual Environments for Fieldwork," *British Cartographic Society Annual Symp.*, 1997; available at <http://www.geog.le.ac.uk/mek/VirtEnv.htm>.
2. M. Abernathy and S. Shaw, "Integrating Geographic Information in VRML Models," *Proc. Third Symp. VRML*, ACM New York, 1998, pp. 107-114.

Guided by these functionality in a loading data over t oped a custom ter TerraVision II that tures. Although n TerraVision II lets th level optimizations seamless interaction We designed our maintenance and to lar sets of geo-refer Java scripting to ex the External Authori fic management of To help develop s graphical represent Lee Iverson formed group, an official We mium (<http://www.a> he VRML communit made freely available ll of the tools we dev data sets. This includ om VRML nodes an generate the VRML c

Explore Litigation Insights

Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

Real-Time Litigation Alerts



Keep your litigation team up-to-date with **real-time alerts** and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

Advanced Docket Research



With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

Analytics At Your Fingertips



Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

LAW FIRMS

Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

FINANCIAL INSTITUTIONS

Litigation and bankruptcy checks for companies and debtors.

E-DISCOVERY AND LEGAL VENDORS

Sync your system to PACER to automate legal marketing.