



GraphiCon'98 Tutorial:

Introduction to VRML 97

Ralf Dörner, Colette Elcacho, Arno Schäfer
Fraunhofer Institute for Computer Graphics
Darmstadt, Germany

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Outline (I)

15 min

Introduction
Overview

60 min

VRML'97 Basic Concepts

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Outline (II)

20 min

VRML'97 Features

60 min

VRML and Java:
Programming of 3D Worlds

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Outline (III)

25 min

VRML Browsers and Tools
Current Developments
Literature
Questions & Answers

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INTRODUCTION

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What is VRML ?

- Virtual Reality Modeling Language
- 3D Description *Language*
(No software system)
- Implementation of the language specification by *VRML - Browser*
- Standardized language:
One VRML - *Scene* for different browsers

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VRML Example (I)



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VRML Example (II)



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VRML: History (I)

- 1994 Mark Pesce, Tony Parisi, Gavin Bell start with the idea of extending the Internet standard HTML in San Francisco
- Mid 1995: VRML 1.0 based on SGI's Open Inventor after an "Internet vote" decision
- Start of the support from SGI, Netscape and Microsoft

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VRML: History (II)

- VRML Architecture Group (VAG) founded at SIGGRAPH'95
- Spring 1996 Call for proposals concerning VRML 2.0 by the VAG
- VRML 2.0 specification release at SIGGRAPH'96 after open vote (based on SGI's Moving Worlds proposal)
- Foundation of the VRML consortium

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VRML: History (III)

- Early 1997 Start of ISO - standardization ("VRML 97")
- End 1997 VRML 97 is standardized as ISO/IEC DIS 14772-1

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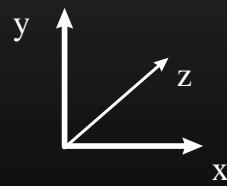
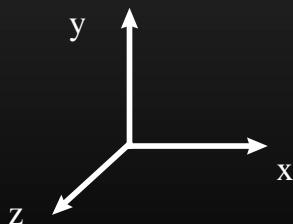
BASIC CONCEPTS

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The 3D World

- Coordinate systems
 - right-handed vs. left-handed



- 3D - coordinates, e.g. (2.0, 1.5, 7.21)

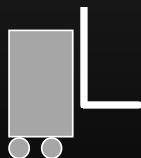
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Global vs. Local Coordinates

- Hierarchy of coordinate systems
- Example: Fork of forklift truck
 - Coordinates of fork with regard to truck
 - Coordinates of truck with regard to world



- Top of the hierarchy: World Coordinates

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The Scene Graph

- Visualization of the scene hierarchy
- Edges: Dependency relation
- Nodes:
 - Geometry
 - Transformations
 - Material attributes
 - ...
- Fields

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A VRML File

```
#VRML V2.0 utf8
Shape {
    appearance Appearance {
        material Material { }
    }
    geometry Cone {
        bottomRadius 2.4
        height 5.0
    }
}
```

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Structure of a VRML File (I)

- VRML Header
 - Version
 - Character Set,
e.g. UTF-8 (ISO 10646-1:1993)
- Line comments (Beginn mit #)
- VRML nodes and fields
- Relations with curly braces { }

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Grouping of Nodes

- Combination of nodes to a group:
Group Node
- *Example:*
Group{
 children [
 Shape{ ...}
 Shape{ ...}
]
}

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Transformations (I)

- Translation
Translation vector: (x , y , z)

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Transformations (II)

- Rotation
 - Rotation axis: (x, y, z)
Note: only direction relevant
 - Rotation angle: φ
Note: sign of angle is determined with the “Right-Hand-Rule”
Note: Angels are measured in radian
($\pi = 3, 14\dots$ entsprechen 180°)
 - Rotation center: (x, y, z)

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Transformations (III)

- Scaling
 - Scaling factors: (s_x , s_y , s_z)
 - Rotation axis: (x, y, z)
 - Rotation angle: ϕ

Note:

1. Scaling rotation
2. Scaling
3. Back rotation

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Transform Node

- Representation of transformations in VRML by the use of a *Node*
- Values for specifying the transformation are provided in *Fields*
Example: rotation 4.0 0.0 0.0 2.37
- Special field with list of nodes affected by the transformation
Example: children []

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Transform Node: An Example

```
Transform{
    children [ Shape {
        appearance Appearance{
            material Material { }
        }
        geometry Box { } }
    ]
    translation 0.0 4.0 0.3
    rotation    1.0 0.0 1.0 1.57 }
```

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VRML Types (I)

- Single Field Values (SF)
Multiple Field Values (MF)
- SFBool TRUE, FALSE
- SFI32 42
MFInt32
- SFFloat -124.567
MFFloat

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VRML Types (II)

- SFString “forklift truck”
MFString
- SFTime 65
(specifies 12 a.m. 1 Minute
5 Sec. GMT on 1.1.1970)
- SFNode Transform
MFNode
- SFLImage

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VRML Types (III)

- SFVec2f 1.3 4.5
MFVec2f
- SFVec3f 34.5 -4.9 9.0
MFVec3f
- SFRotation 1.0 1.0 4.0 3.2
MFRotation
- SFCOLOR 1.0 0.0 0.0
MFColor

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DEF - USE Mechanism

- Nodes may be named
Example: DEF my_box Box { ... }
- Names
 - consist of letters, digits and underscore
 - start with capital letter
 - distinguish capitalization
 - Nodes may be used arbitrary times
Example: USE my_box

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Reserved Names in VRML

DEF	EXTERNPROTO	FALSE
IS	eventIn	TRUE
TO	eventOut	PROTO
NULL	exposedField	ROUTE
USE	field	



Events and Routes (I)

- Event
 - Change of a value
 - User interaction
- Route
 - Connection of two nodes in order to exchange events
 - Start node (source)
 - End node (drain)

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Events and Routes (II)

- Routes are related to a field of a node
- Field categories:
 - eventIn
 - eventOut
 - exposedField
 - set_XXX
 - XXX_changed
- Events and routes are typed

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Routing: Example

```
DEF myCube Transform{  
    ...  
}  
DEF myBox  Transform{  
    ...  
}  
ROUTE myCube.translation_changed TO  
    myBox.set_scale
```

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Syntax of VRML Nodes

- Node name
- Field list
- For each field
 - Name
 - Defaultvalue
 - field, eventIn, eventOut, exposedField
 - Type

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Example: TimeSensor Syntax

TimeSensor

exposedField	SFBool	enabled	TRUE
exposedField	SFTime	startTime	0
exposedField	SFTime	stopTime	0
exposedField	SFTime	cycleInterval	1
exposedField	SFBool	loop	FALSE
eventOut	SFBool	isActive	
eventOut	SFBool	time	
eventOut	SFTime	cycleTime	
eventOut	SFFloat	fraction_changed	

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TimeSensors

loop = TRUE	stopTime <= startTime	Endless cycles
loop = TRUE	startTime < stopTime	Cycles till stopTime
loop = FALSE	stopTime <= startTime	1 Cycle, Stop at startTime + cycleInterval
loop = FALSE	startTime < stopTime	1 Cycle, Stop at startTime + cycleInterval or stopTime, if it is earlier

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Animation

- Timer
- Interpolator
 - PositionInterpolator
 - ColorInterpolator
 - ScalarInterpolator
 - ...
- Routing: Timer > Interpolator
 Interpolator > Animated Value

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PositionInterpolator

- Mapping of a value out of an interval (usually [0.0, 1.0]) to a position
- Input: set_fraction (SFFloat)
- Output: value_changed (SFVec3f)
- Calculation of values using linear interpolation based on a table
 - key [0.0, 1.0]
 - keyValue [1.0 0.0 0.0, 5.0 0.0 0.0]

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Routing Example for Animation

Box is a Transform Node with Shape

BoxPath is a PositionInterpolator Node

Timer is a TimeSensor Node

```
ROUTE Timer.fraction_changed TO  
      BoxPath.set_fraction
```

```
ROUTE BoxPath.value_changed TO  
      Box.set_translation
```



Inlines

- Including VRML files in a VRML file
- Example:

```
Inline {
    url "example.wrl"
}
```
- Different name space concerning DEF / USE

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Prototypes (I)

- Encapsulation of parts of a scene graph
- Own node definition
- Parameterizable
- Syntax:
PROTO *name* [*interface*] { *body* }
- Building a connection between *interface* and *body* using IS syntax

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Prototypes (II)

```
PROTO Box [  
    field SFVec3f dimension 1.0 1.0 1.0  
] {  
    Shape { appearance Appearance{  
        material Material{} } }  
    geometry Box{  
        size IS dimension{} }  
}
```

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Prototypes (III)

- DEF / USE has its own name space
- Connection interface and body

		Prototyp-Declaration			
		exposedField	field	eventIn	eventOut
Prototyp-Definition	exposedField	+	+	+	+
	field	-	+	-	-
	eventIn	-	-	+	-
	eventOut	-	-	-	+

- Prototypes may be nested



External Prototypes

- Syntax:
EXTERNPROTO *name* [*interface*] { *urls* }
- Creation of prototype libraries
- Example:

```
EXTERNPROTO Box [
    field SFVec3f dimension 1.0 1.0 1.0
]{
    "lib.wrl#Box"
}
```



Structure of a VRML File (II)

- VRML - Header
- Comments
- Prototype - Definitions
- Nodes and Fields
- Routes

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VRML Basics: Conclusion

- Scene graph concept:
Nodes and Fields
- Routing concept:
EventIn, EventOut, Routes
- VRML Syntax:
Data types, field types
- VRML file structure
- Naming mechanism, Prototypes, Inlining

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VRML FEATURES

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Features: Geometry (I)

- Predefined Shapes
 - Cube
 - Cylinder
 - ...
- Polygonal Shapes
 - Coordinate node
 - Line Sets / Indexed Line Sets
 - Face Sets / Indexed Face Sets

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Features: Geometry (II)

- Elevation Grids
(esp. for terrains)
- Extrusion nodes
(extruding cross sections along a spine)
- Level of detail (LOD node)

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Features: Appearance

- Material node
 - Specularity, Shininess, ...
 - Transparency
 - Color
- Appearance node
 - Material
 - Texture

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Features: Texturing

- ImageTexture node
- PixelTexture node
- MovieTexture node
- TextureCoordinate node
- TextureTransform node
(controls mapping)

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Features: Text

- Text node
 - Maximum extent, length
 - Text itself
- FontStyle node
 - Font family, style
 - Spacing
 - Justification

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Features: Transformation

- Rotation
- Scaling
- Positioning

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Features: Grouping Nodes

- Group node
- Transform node
- Switch node
(activates different parts of scene graph)
- Billboard node
(groups z-axis always points to viewer)

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Features: Animation

- TimeSensor
- Interpolators
 - PositionInterpolator
 - ColorInterpolator
 - CoordinateInterpolator
 - OrientationInterpolator
 - ScalarInterpolator

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Features: Sensors

- TouchSensor node
- PlaneSensor node
- SphereSensor node
- CylinderSensor node
- VisibilitySensor node
- ProximitySensor node
- Collision node

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Features: Environment

- Background node
 - Sky angle (upper half sphere)
 - Ground angle (lower half sphere)
 - Color gradients
- Fog node

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Features: Lights

- Light sources:
 - PointLight node
 - DirectionalLight node
 - SpotLight node
- Default light (Headlight) mounted to the viewer
- NO shadows

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Features: Shading

- Normal node
- NormallInterpolator node

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Features: Viewer and Infos

- Viewpoint node
(defines viewer position and view)
- NavigationInfo node
(type, speed, size of viewer avatar)
- WorldInfo node
(title, info, e.g. copyright info)

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Features: Sound

- AudioClip node
(sound source, duration, ...)
- Sound node
(intensity, range, spatialization, ...)

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Features: Hypermedia

- Anchor node
- Semantic: if user clicks shape then new world is loaded

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Features: Reusing

- Inline node
- PROTO construct
- EXTERNPROTO construct

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Features: Program logic

- Script node
- Including Java or ECMAScript programs

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VRML-Features: Conclusion

- VRML is a description language for interactive 3D worlds
- VRML integrates animation, multimedia and hypermedia
- VRML may be transmitted via Internet / WWW
- VRML may be implemented using immersive technologies

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VRML & PROGRAMMING

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VRML and Program Logic (I)

- Integration of programs of arbitrary complexity
- Programs may manipulate the VRML scene
- Application examples
 - Multi-User Systems
 - Database Linkage
 - Simulations

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VRML and Program Logic (II)

- Two different approaches
 - VRML Scripting Interface
 - External Authoring Interface (EAI)

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VRML Scripting

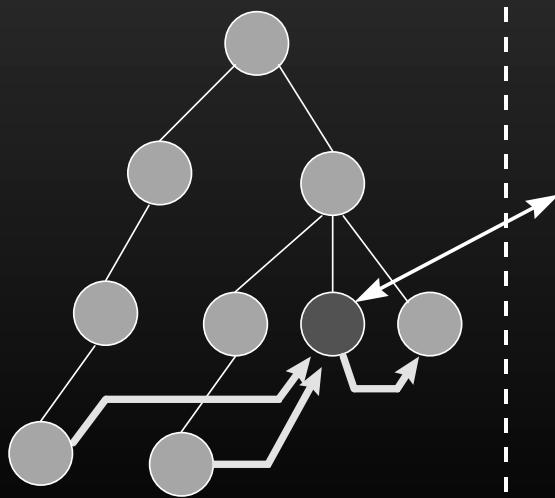
- Embedding of programmed behavior in a VRML scene
- Supported programming languages:
 - Java
 - ECMAScript (JavaScript)
- Programming interfaces (“APIs”) are part of the VRML specification

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VRML Scripting: Idea



myScript.java:

```
public class myScript extends Script {  
    public void initialize () {  
        // ...  
    }  
  
    public void processEvent (Event e) {  
        // ...  
    }  
}
```

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VRML Scripting: Idea

- On the VRML side:
Script Node with
 - user-defined interface analogous to PROTO definitions
 - reference to the Java program
- On the Java side:
 - dedicated API for communication with the VRML scene

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The Script Node: Syntax

```
Script {  
    exposedField MFString url          []  
    field        SFBool    directOutput FALSE  
    field        SFBool    mustEvaluate FALSE  
  
    # and an arbitrary number of  
    eventIn     eventType eventName  
    field        fieldType fieldName initialValue  
    eventOut    eventType eventName  
}
```

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The url-Feld

- Reference to an external file

```
url "http://bla.fasel.de/meinScript.class"  
url "meinScript.js"
```

- Inline-Program

```
url "javascript: function bla() {...}"
```

- Alternative URLs

```
url [ "javascript: ..."  
      "java_version.class"  
    ]
```



directOutput und mustEvaluate

- directOutput
 - has to be TRUE if the script manipulates nodes directly (instead of using routing mechanism)
- mustEvaluate:
 - if FALSE, browser may defer event delivery to the script under special circumstances

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Definable Fields

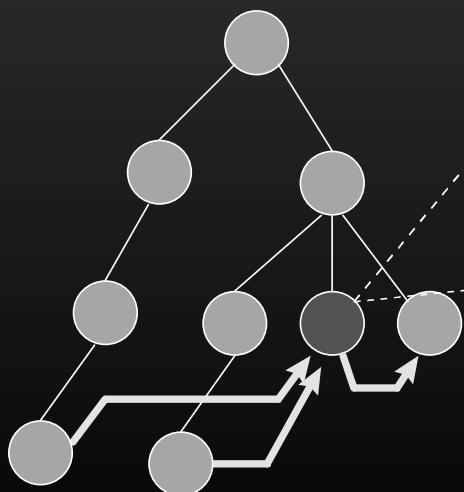
- In a Script node an arbitrary number of fields, eventIns and eventOuts (no exposedFields) can be defined
- *Fields* can be read and modified by the script
- *Fields* are therefore well suited for parameterizing of the script

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Script Node Example (I)



```
Script {
    url "myScript.class"
    field SFFloat height 10.0
    eventIn SFBool click
    eventOut SFTime start
}
```

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Script Node Example (II)

```
Script {  
    url "myScript.class"  
  
    # field typ name wert  
    field SFFloat height 10.0  
    # eventIn typ name  
    eventIn SFBool click  
    # eventOut type name  
    eventOut SFTime start  
}
```

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The Java Programming Interface

- Specifies the interaction between Java programs referred in Script nodes and the browser / scene
- Currently supports Java 1.0
- Enables the use of the complete Java functionality, such as network or GUI functions

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Data Types

- Every VRML data type has two corresponding Java classes:
 - Read Only Type
e.g. ConstMFString
 - Read / Write Type
e.g. SFTime

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Read Only Types

```
public abstract class ConstMFField extends ConstField {  
    public abstract int getSize();  
}  
  
public class ConstMFString extends ConstMFField {  
    public ConstMFString(int size, String s[]);  
    public ConstMFString(String s[]);  
  
    public void getValue(String values[]);  
    public String get1Value(int index);  
    public String toString();  
}
```

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Read / Write Types

```
public class SFTime extends Field {  
    public SFTime();  
    public SFTime(double time);  
  
    public double getValue();  
  
    public void setValue(double time);  
    public void setValue(ConstSFTime time);  
    public void setValue(SFTime time);  
  
    public String toString();  
}
```

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Field Access (I)

- The fields defined in the Script node can be accessed using the “getField”, “getEventIn”, and “getEventOut” methods of the Script class (type casting may be necessary)
- The values of the fields can be read using the respective “getValue” methods

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Field Access (II)

VRML

```
Script {  
    url "meinScript.class"  
    field SFFloat height 10.0  
    eventIn SFBool click  
    eventOut SFTime start  
}
```

Java

```
SFFloat field_height = (SFFloat) getField  
("height");  
float value = field_height.getValue();
```

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Field Access: Example

```
// SF-Felder  
SFFloat field_height = (SFFloat) getField  
("height");  
float value = field_height.getValue ();  
  
// MF-Felder  
MFString field_strings = (MFString) getField  
("strings");  
String[] value2 =  
    new String[field_strings.getSize ()];  
field_strings.getValue (value2);
```

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Initialization

- In the script a method “initialize” can be defined, that is called by the Browser before the script receives the first event
- Often the initialize method creates references to the fields and event interfaces defined in the script node and stores them for later use

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Initialization: Example

```
import vrml.*;
import vrml.node.*;
import vrml.field.*;

public class myScript extends Script {

    public void initialize () {
        SFFloat height = (SFFloat) getField ("height");
        float value = height.getValue ();

        // ...
    }
}
```

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Manipulation of a VRML Scene

- Reading of data
- Reception of events
- Sending of events and changing values
 - Manipulation via routing mechanism
 - Direct manipulation
- Dynamic scene graph manipulation
 - adding / deleting nodes
 - adding / deleting routes

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Script EventIns

- EventIns of a Script node are connected with the scene via ROUTEs
- When an event is passed via a ROUTE into an Script node, the “processEvent” method of the script is called

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Reception of Events (I)

- Methods

```
public void processEvent (Event e) {}
```

- Event Class

```
public class Event {  
    public String getName ();  
    public double getTimeStamp ();  
    public ConstField getValue ();  
}
```

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Reception of Events (II)

VRML

```
Script {
    url "myScript.class"
    field SFFloat height
10.0
    eventIn SFBool click
    eventOut SFTime start
}
```

Java

```
public void processEvent (Event e) {
    String name = e.getName ();

    if (name.equals ("click")) {
        ConstSFBool t = (ConstSFBool)
            e.getValue ();
        boolean value = t.getValue ();
        // ...
    }
}
```

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Reception of Events: Example

```
public void processEvent (Event e) {  
    String name = e.getName ();  
  
    if (name.equals ("click")) {  
        ConstSFBool t = (ConstSFBool) e.getValue ();  
        if (t.getValue () == false) {  
            // ...  
        }  
    }  
    else if (name.equals ("foo...")) {  
        // ...  
    }  
}
```

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Sending of Events (I)

- eventOuts of a Script node are connected with the scene via ROUTEs
- The script gets a pointer to the eventOut using the “getEventOut” method
- By calling “setValue” on the eventOut object, the event is sent to the scene

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Sending of Events (II)

VRML

```
Script {
    url "meinScript.class"
    field SFFloat hoehe 10.0
    eventIn SFBool click
    eventIn SFTime zeit
    eventOut SFTime start
}
```

Java

```
private SFTime eventout_start;

public void initialize () {
    eventout_start = (SFTime) getEventOut
        ("start");
}

public void processEvent (Event e) {
    if ( /* best. Event Empfangen */ ) {
        eventout_start.setValue
            (e.getTimeStamp ());
    }
}
```

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Sending of Events (III)

- EventOut declaration in Script node

```
eventOut SFTime start
```

- Manipulation in script-code

```
private SFTime eventout_start;
public void initialize () {
    eventout_start = (SFTime) getEventOut ("start");
}
public void processEvent (Event e) {
    if ( /* certain event received */ ) {
        eventout_start.setValue (e.getTimeStamp ());
    }
}
```

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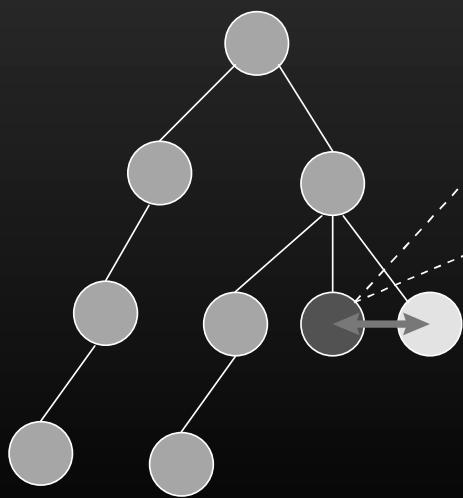
Direct Manipulation of Nodes (I)

- Sending events to a node without routing
- directOutput - field of Script node needs to be TRUE
- Script needs to have reference to the node
- Reference to the node may be obtained for example via a SFNode-Field where “USE - references” to another node are stored

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Direct Manipulation of Nodes (II)



```
Script {
  url "meinScript.class"
  field SFNode myRef USE aNode }
```

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Direct Manipulation of Nodes (III)

- Fields/EventIns of a node are read using the “getExposedField” or “getEventIn” method respectively
- The “children” - field of a Group node offers the possibility to access its child nodes and thus to traverse the whole scene graph

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Direct Manipulation of Nodes (IV)

- Field declaration in a script node

```
field SFNode light USE aLightNode  
directOutput TRUE
```

- Manipulation in the script code

```
SFNode f_light = (SFNode) getField ("light");  
Node lightNode = (Node) f_light.getValue ();  
SFBool f_on = (SFBool) lightNode.getExposedField  
("on");  
boolean value = f_on.getValue ();  
f_on.setValue (!value); // Light on / off
```



The Browser Class (I)

```
public class Browser
{
    public String getName();
    public String getVersion();
    // For identification of the browser

    public float getCurrentSpeed();
    // Navigationspeed (m/s)

    public float getCurrentFrameRate();
    // Frame-Rate (images/s)
```

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The Browser Class (II)

```
public String getWorldURL();
// URL of the current world

public void replaceWorld(BaseNode[] nodes);
public void loadURL(String[] url, String[] parameter)
    throws InvalidVRMLSyntaxException;
// replace current world

public void setDescription(String description);
// set world description of browser (e.g. window title)
```



The Browser Class (III)

```
public BaseNode[ ] createVrmlFromString(String  
vrmlSyntax)  
    throws InvalidVRMLSyntaxException;  
// create new VRML nodes  
  
public void createVrmlFromURL(String[ ] url, BaseNode  
node, String event)  
    throws InvalidVRMLSyntaxException;  
// insert external file into scene
```



The Browser Class (IV)

```
public void addRoute(BaseNode fromNode, String
fromEventOut, BaseNode toNode, String toEventIn);
public void deleteRoute(BaseNode fromNode, String
fromEventOut, BaseNode toNode, String toEventIn);
// Create / delete routes dynamically
}
```

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Dynamic Routing

- using “addRoute” and “deleteRoute”- methods of the browser class
- References to the participating nodes and the field names are needed

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Dynamic Routing: Example

```
private SFNode field_fromNode;
public void initialize () {
    feld_fromNode = (SFNode) getField ("fromNode");
}
public void processEvent (Event e) {
    if (e.getName ().equals ("trigger_event")) {
        getBrowser ().addRoute (field_fromNode.getValue (),
                               "isActive", this, "clicked");
    }
    else if (e.getName ().equals ("clicked")) {
        // do something
    }
}
```

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Creation of new VRML Nodes

- using “createVrmlFromString” method
- complex VRML structure may be generated using the Java classes especially the script classes

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Creation of new VRML Nodes: Example

```
SFNode f_aGroupNode = (SFNode) getField ("aGroupNode");
Node aNode = (Node) f_aGroupNode.getValue ();
MFNode f_children = (MFNode) aNode.getExposedField
("children");

Browser myBrowser = getBrowser ();
BaseNode[] nodes = null;
try {
    nodes = myBrowser.createVrmlFromString ("Box {}");
} catch (InvalidVRMLSyntaxException x) {}

f_children.addValue (nodes[0]);
```

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What is missing?

- Possibility to address VRML browser externally
- Possibility to address VRML scene from an applet
- Possibility to integrate VRML scene in a hypermedia context

→ EAI (External Authoring Interface)

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EAI: History

- Developed by Chris Marrin, Silicon Graphics, Inc.
- Proposal for extension of VRML97 standard
- First version: 01. April 1997
- Current version: 21. November 1997
- Revised version: 8. April 1998

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EAI: Official VRML Working Group

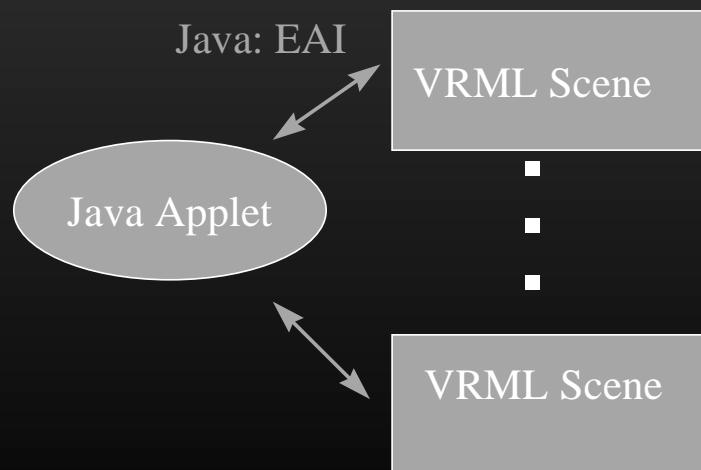
- New proposal announced for SIGGRAPH'98 (Mid July)
- Java implementation supports
 - Netscape, MSIE
 - Cosmo Player (SGI), Intervista WorldView, VrWave, Blaxxun Interactive CC3D

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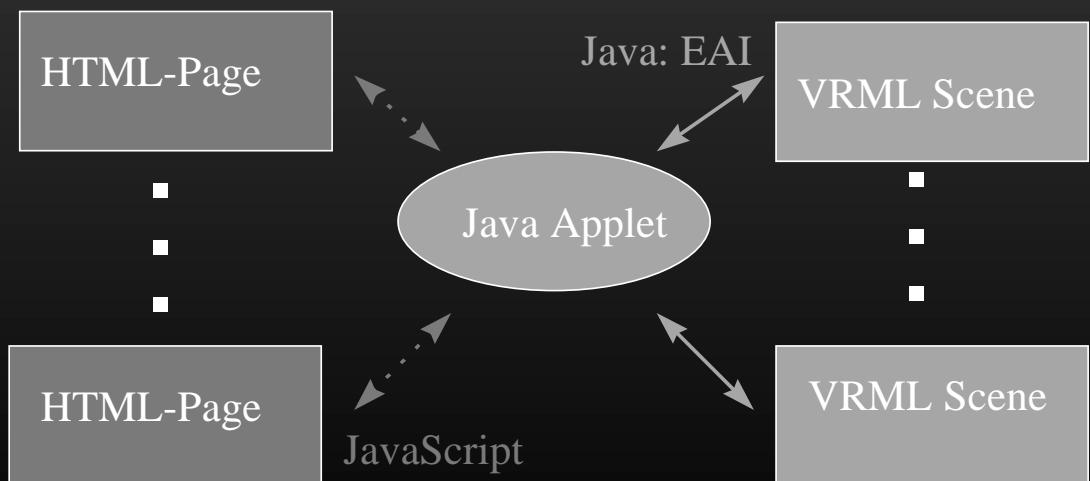
EAI: Interfaces (I)



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EAI: Interfaces (II)



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EAI: The HTML Start Page

```
<HTML>
<TITLE>My First Page</TITLE>

<BODY>
<EMBED src="myScene.wrl">
<APPLET code="myApplet.class" mayscript>
  <PARAM name="..." value="...">
  ...
</APPLET>

</BODY> </HTML>
```

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EAI: The Interface Classes

- Using classes of the `vrml.external.*` package
 - `vrml.external.Browser`, `vrml.external.Node`
 - `vrml.external.field` (`EventIn`, `EventOut`, `EventObserver`)
 - `vrml.external.exception`
- NOT identical to the Java scripting classes `vrml`, `vrml.node.*` and `vrml.field.*`

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The Java Applet

```
import java.applet.*;
import vrml.external.Browser;
...
public class myApplet extends Applet {
    Browser b;
    public myApplet {
        b= Browser.getBrowser(this);
        ...
    }
}
```

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Reference to the Browser



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The Browser Class (I)

Access to the Applet:

- static public Browser getBrowser (Applet applet);
- static public Browser getBrowser (Applet applet, String frameName, int index);

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The Browser Class (II)

Information about the current browser status:

- public String getName();
- public String getVersion();
- public float getCurrentSpeed();
- public float getCurrentFrameRate();
- public String getWorldUrl();



The Browser Class (III)

Modifying the scene:

- replaceWorld (Node[] nodes);
- loadURL (String[] url, String[] parameter);
- createVrmlFromString (String vrmlsyntax);
- createVrmlFromURL (String[] url, Node node, String event);

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The Browser Class (IV)

Modifying the scene(II):

- addRoute();
- deleteRoute();

Obtaining references of a named node:

- public Node getNode(String name);



Accessing Nodes

Example:

```
DEF Entry Viewpoint {  
...  
}
```



```
Node Entry = b.getNode("Entry")
```

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The Node Class

- Accessing information about nodes
 - public String getType();
 - public EventIn getEventIn();
 - public EventOut getEventOut();

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Applet - VRML Communication

- Direct Manipulation of Nodes
 - Reading & writing of fields
- EventOutObserver for monitoring events in the VRML scene

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Reading Access: Example

VRML-Szene:

```
DEF move_me transform{ ... } ...
```

Java-Applet:

```
Browser b= Browser.getBrowser(this);  
...  
Node move_me = b.getNode("move_me");  
EventOutSFVec3f field_translation =  
(EventOutSFVec3f)move_me.getEventOut("translation");
```

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Writing Access: Example

Java Applet:

```
Browser b= Browser.getBrowser(this);
...
Node move_me = b.getNode("move_me");
EventInSFVec3f field_translation =
(EventInSFVec3f) move_me.getEventIn("set_translation");
float value[3] = new float[3];
value[0] = 14 ; value[1] = 7; value[2] = 89;

field_translation.setValue(value);
```

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Receiving Events (I)

- Routing mechanism cannot be used with Applets
- VRML scene and applet are independent

→ Event Handling Mechanism:
EventOutObserver Class



Receiving Events (II)

- Applet implements the EventOutObserver interface
- Events are registered at the EventOutObserver using the advise method
- Reaction to the event is specified in the callback method

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EventOutObserver Interface (I)

```
public class MyObserver implements EventOutObserver{  
    ...  
    public void callback (EventOut value,  
                         double timeStamp,  
                         Object userData)  
    {  
        // Casting and Evaluation of the Out Event  
    }  
}
```

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EventOutObserver Interface (II)

```
class myApplicationClass{
    myApplicationClass() {
        Browser b = Browser.getBrowser(this);
        Node time = b.getNode ("time");
        // Creating EventOutObserverObject
        MyEventObserver ob =
            new MyEventObserver();
        // Registering callbacks
        time.getEventOut("fraction_changed").advise(ob,null);
    }
}
```

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EventOutObserver Interface (III)

```
public class MyApplet extends Applet implements  
    EventOutObserver{  
    ...  
    public void init(){  
        Browser b = Browser.getBrowser(this); ...  
        Node time = b.getNode ("time");  
            // Registering callback  
        time.getEventOut("fraction_changed").advise(this,null);  
    }  
    public void callback (EventOut value, double timeStamp,  
        Object data) { ...}
```

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JavaScript and VRMLScript

- Programs may be written in the VRML file
- JavaScript developed by Netscape
- JavaScript standardized by ECMA: ECMAScript
- VRMLScript developed by SGI
- VRMLScript is special subset of JavaScript

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JAVAScript and VRMLScript

```
DEF Blow Script {
    eventIn SFBool touch
    eventOut SFInt32 whichChoice
    url [ "javascript:
        function initialize () { whichChoice=1; }
        function touch (eventValue){
            if (whichChoice == 2)
                whichChoice = 0;
            else whichChoice++;
        }
    "choice.class" ]
}
```

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VRML Programming: Conclusion

- Different languages:
 - Java
 - ECMAScript
- Different API
 - VRML Scripting using Script node
 - External authoring interface (EAI)

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MISCELLANEOUS

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VRML Authoring

- Integrative nature of VRML requires the use of many different tools in the authoring process:
 - Geometry modellers
 - Scene composition tools
 - Programming tools (e.g. Java compiler/IDE)
 - Browsers
 - Data Converters
 - Texture editors
 - Video/sound tools

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Performance / Scene complexity

- No. of Polygons: about 4000 triangles max. without 3D hardware (especially for distribution on the WWW)
- Too many textures may also be a bottleneck
- Limit number of Java threads

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Performance / Scene complexity

- Use interpolators und ROUTEs sparingly
- Use LOD
- Many Light sources have a great impact on performance
- Limit Size of .wrl file (when distributed on the Net)
⇒ use “gzip” compression

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Tools: VRML Browsers

- Typically free of charge
- Most often installed as “plugin” or “ActiveX Control” (Netscape/MS Internet Explorer)
- Installation of more than one Browser results typically in problems

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Tools: VRML Browsers

- COSMO Player 2.0
 - Windows
 - EAI, Java, JavaScript, VRMLScript
- Worldview 2.1
 - Windows
 - EAI, Java, JavaScript

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Tools: VRML Browsers

- Sony Community Place PRD2
 - Windows
 - Java
- CASUS Presenter
 - Windows, Sun, SGI, Linux
 - EAI, Java

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Tools: 3D World Builders

- ac3d
free modeller, only for creation of geometry
- Caligari TrueSpace 3
Animation system
- COSMO Worlds
very powerful, SGI and PC

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Tools: 3D World Builders

- V-Realm Builder 2.1
Animation system specially for VRML
- Internet 3D Space Builder aka
Cosmo Home Space Designer
creation of static worlds

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Other tools

- VRML Generators (e.g. automatic visualization of directory structure)
- LOD Generators
- Converters (e.g. for dxf, obj format)
- VRML Parsers
- VRML Syntax Checkers
- Test Suites

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Application examples

- Entertainment, e.g. virtual Lego-blocks
- Edutainment, e.g. space exploration
- Visualization of scientific data
- Biology, e.g. “visible human”
- Physics, e.g. visualization of electric fields

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Application examples

- Chemistry, e.g. molecule editing
- Navigation aids for WWW, e.g. 3D Hyperlinks
- Catalogue systems (virtual warehouse)
- Virtual exhibition booth
- Visualization of production processes in industry

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Application examples

- Arts, e.g. Choreography
- Virtual Museum
- Architecture, Urban development
- Marketing, e.g. “Banner ads”
- Database visualization

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Current developments

VRML Working Groups:

- MPEG-4 Integration
- DHTML Integration
- DBWork (Database connectivity)
- Compressed Binary Format
- Humanoid Animation
- Multi user support

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Current developments

- Browser Conformance
 - DIS (Distributed Interactive Simulation)
 - GeoVRML
 - User Input (e.g. keyboard input)
 - Objekt oriented VRML
 - VRML Data Streaming
- ⇒ New version of standard expected in
1999

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Java 3D

- 3D API for Java
- Does not specify a file format
- Based on a scene graph model
- Specification 1997
- First implementation march 1998

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References: WWW (I)

- VRML Repository
<http://www.sdsc.edu/vrml/>
comprehensive list of links around VRML
- VRML Consortium home page
<http://www.vrml.org/>
The consortium has the goal of promoting
and furthering the development of VRML

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References: WWW (II)

- COSMO Home page
<http://cosmosoftware.com/>
VRML Tools and links to interesting VRML worlds
- Javasoft Home page
<http://www.javasoft.com/>
Everything around Java

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References: WWW (III)

- The Mining Company
<http://vrml.miningco.com/>
Another repository of VRML related information

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References: mailing lists

- General VRML mailing list:
majordomo@vrml.org
subscribe www-vrml
- Several working group mailing lists

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References: books (I)

- VRML 2.0 Source Book
Ames, Nadeau, Moreland
Wiley, 1996
- Annotated VRML Reference Manual
Bell, Carey
Addison-Wesley, 1997
- Teach Yourself VRML in 21 Days
Marrin, Campbell
SAMS Net, 1997

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References: books (II)

- The VRML 2.0 Handbook
Hartman, Wernecke
Addison-Wesley, 1996
- Late Night VRML 2.0 with Java
Roehl, Couch et al.
ZD Press, 1997
- JAVA for 3D and VRML Worlds
Lea, Matsuda, Miyashita
New Riders, 1996

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Questions & Comments

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