



Supporting Mixed Reality Visualization in X3D Standards

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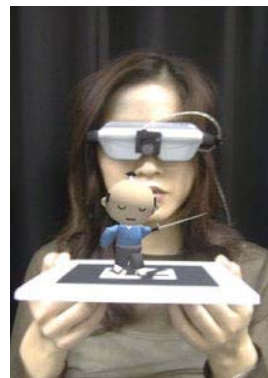
Mixed Reality and X3D Standard

Augmented Reality

- What is AR (Augmented Reality) ?
 - "Augmented Reality (AR) is a field of computer research which deals with the combination of real-world and computer-generated data." – wikipedia.org
- Key Features of AR [R. Azuma 97]
 - Combines real and virtual images
 - Interactive in Real-Time
 - Registered in ~~3D~~ Real World



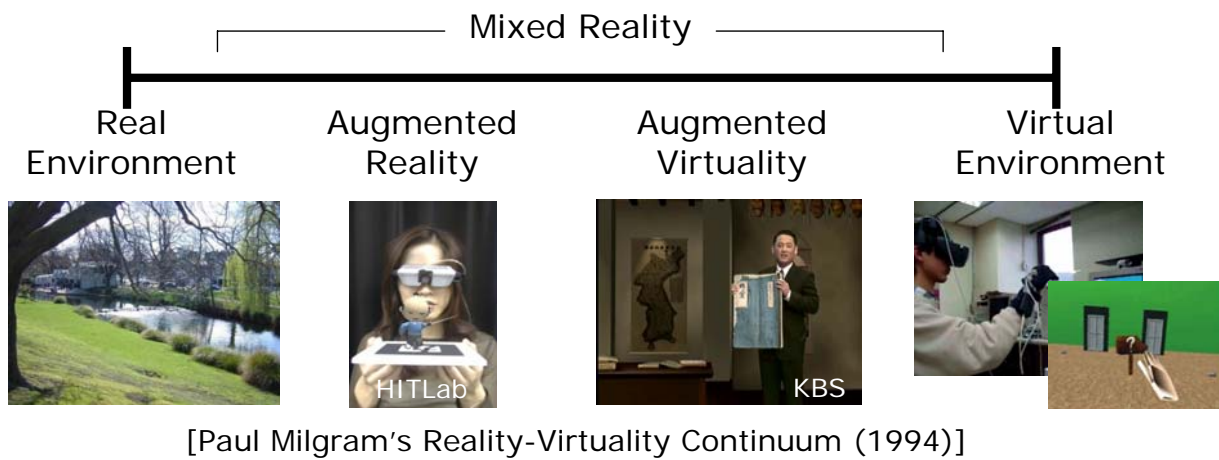
STAR System
[HRL Laboratories, 1998]



ARToolkit
[HITLab, Univ. of Washington, 1999]

Mixed Reality

- What is MR (Mixed Reality) ?



Mixed Reality and X3D Standard

- Does MR need X3D?
 - Today, MR researches mostly focus on interfaces
 - Tracking
 - Visualization
 - Hardware interfaces
 - Interaction methods
 - Becoming one of mainstream media: Interface => Contents
 - As a content, it has to be ...
 - Easily shared
 - Easily published and distributed
 - Internet (WWW) **IS** the place where we share contents
 - MR systems already use VRML and X3D for geometry data
- Does X3D need MR?
 - Why not?
 - Extending its power of expression
- What do we need more in X3D to support MR?

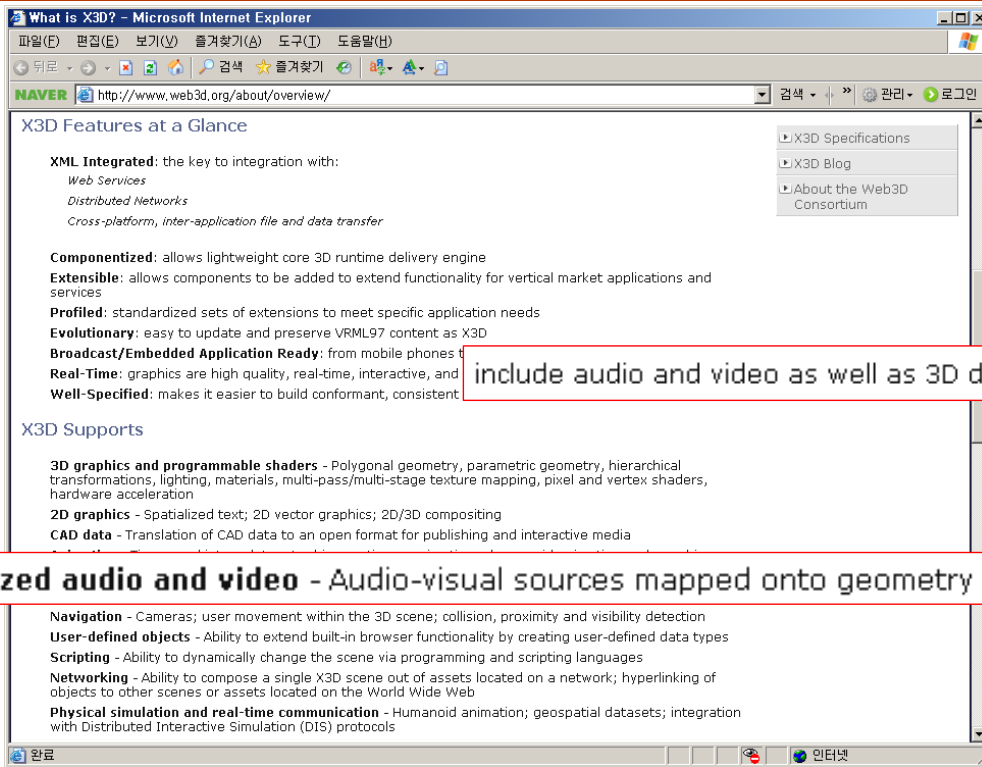
Making X3D become MR capable

- Add real world view
 - Live video (esp. camera on the user's computer)
 - Merging real and virtual image correctly
 - Camera calibration
 - Occlusion
 - Shadow
 - Reflection & Refraction
- Registration
 - Relationship between real and virtual spaces (+ Tracking user's viewpoint)
 - Global and Local coordinates
- Real-time Interactive
 - Tracking (users & other real world objects)
 - Physics, collision-detection, etc.

Topics this talk covers...

Video Supports in X3D Standard

Video Supports in X3D Standard



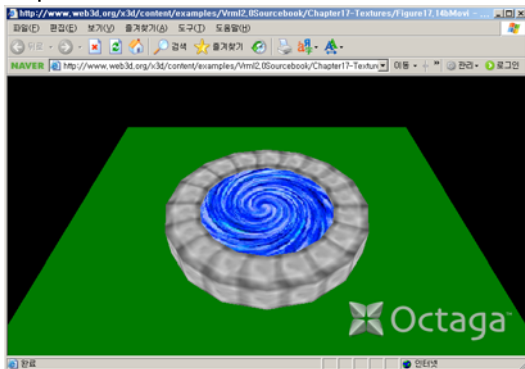
Spatialized audio and video - Audio-visual sources mapped onto geometry in the scene

Navigation - Cameras; user movement within the 3D scene; collision, proximity and visibility detection
User-defined objects - Ability to extend built-in browser functionality by creating user-defined data types
Scripting - Ability to dynamically change the scene via programming and scripting languages
Networking - Ability to compose a single X3D scene out of assets located on a network; hyperlinking of objects to other scenes or assets located on the World Wide Web
Physical simulation and real-time communication - Humanoid animation; geospatial datasets; integration with Distributed Interactive Simulation (DIS) protocols

<http://www.web3d.org/about/overview/>

MovieTexture Node

```
<Shape>
  <Appearance>
    <MovieTexture loop='true' url=' "wrlpool.mpg"
      "http://www.web3d.org/x3d/content/examples/Vrml2.0Sourcebook/wrlpool.mpg" '/>
    </Appearance>
  <IndexedFaceSet ccw='false' coordIndex='0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16'>
  <Coordinate point='2.00 0.6 0.00 1.85 0.6 0.67 1.41 0.6 1.41 0.67 0.6 1.85
    0.00 0.6 2.00 -0.67 0.6 1.85 -1.41 0.6 1.41 -1.85 0.6 0.67 -2.00 0.6 0.00 -1.85 0.6
    -0.67 -1.41 0.6 -1.41 -0.67 0.6 -1.85 0.00 0.6 -2.00 0.67 0.6 -1.85 1.41 0.6 -1.41
    1.85 0.6 -0.67 2.00 0.6 0.00'/>
  </IndexedFaceSet>
</Shape>
```



<http://www.web3d.org/x3d/content/examples/Vrml2.0Sourcebook/Chapter17-Textures/pages/page14.html>



MovieTexture with a webcam video stream [planet9.com]

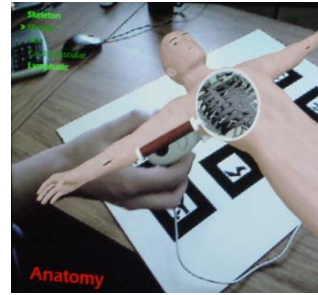
MovieTexture Node

- Limitations as a MR visualization feature
 - Video sources are in URI
 - Needs streaming server for live video camera
 - Delay
 - Lacking of camera parameter information
 - Incorrect depth values
 - Especially not good as an AR background
 - Texture on a billboard has depth values
 - Depth image of the real world required for correct occlusions

Supporting Mixed Reality Visualization in X3D Standard

Live Video Integration

- Live video background
 - Augmented Reality



AR Magic Lens
[HITLab NZ, 2005]

- Live video texture

- Augmented Virtuality
 - Alpha matte – masking background of the real scene
- Applications to visualizing reflections/refractions



History, Special
[KBS, 1998~2003]



Refractive AR
[HITLabNZ, 2007]

Live Video Integration (continued)

- LiveCamera Node (proposed)
 - Child of a scene node
 - Represents a live video camera (on the user's computer)
 - The 'source' field represents device ID (in URN or simple string)
 - The 'image' field provides live video image
 - The 'projmat' field provides internal parameters of the camera
 - 'image' and 'projmat' fields provide distortion corrected data
 - The optional 'position' and 'orientation' fields provide camera tracking data

```
Live Camera {  
  SFString      [in, out]  source  "default"  
  SFImage       [out]      image  
  SFMatrix4f    [out]      projmat "1 0 0 0 ... "  
  SFBool        [out]      on       FALSE  
  SFBool        [out]      tracking  FALSE  
  SFVec3f       [out]      position  
  SFRotation    [out]      orientation  
}
```

Live Video Integration (continued)

■ Extending Background Node

```
<Scene>
  <Background groundAngle='1.309 1.571'
    groundColor='0.1 0.1 0 0.4 0.25 0.2 0.6 0.6 0.6'
    skyAngle='1.309 1.571'
    skyColor='0 0.2 0.7 0 0.5 1 1 1 1'
    backUrl='mountns.png'
    frontUrl='mountns.png'
    leftUrl='mountns.png'
    rightUrl='mountns.png' />
</Scene>
```

```
<Scene>
  <LiveCamera DEF='USBCam1' source='default' />
  <Background liveSource='USBCam1' />
</Scene>
```

```
<Scene>
  <Background videoUrl='bgvideo.mpg' />
</Scene>
```

* Alternatively, new nodes could be defined (e.g., LiveBackground or MovieBackground)

Live Video Integration (continued)

■ Extending MovieTexture Node

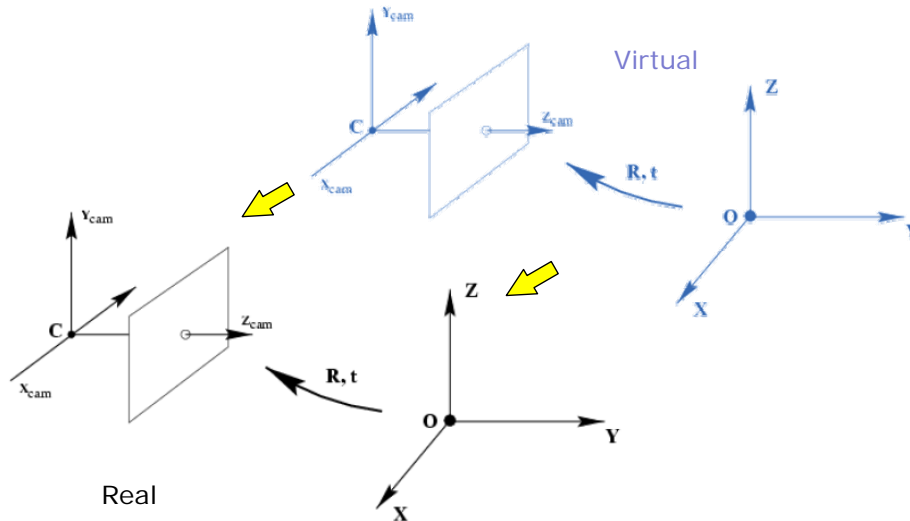
```
<Scene>
  <Shape>
    <Appearance>
      <MovieTexture loop='true' url='wrlpool.mpg' />
    </Appearance>
  <IndexedFaceSet ccw='false' coordIndex='0 1 2 ... 15 16'>
    <Coordinate point='2.00 0.6 0.00 ... 2.00 0.6 0.00' />
  </IndexedFaceSet>
</Shape>
</Scene>
```

```
<Scene>
  <LiveCamera DEF='USBCam1' source='dev#' />
  <Shape>
    <Appearance>
      <MovieTexture liveSource='USBCAM1' keyColor='0 0 1' />
    </Appearance>
  <IndexedFaceSet ccw='false' coordIndex='0 1 2 ... 15 16'>
    <Coordinate point='2.00 0.6 0.00 ... 2.00 0.6 0.00' />
  </IndexedFaceSet>
</Shape>
</Scene>
```

Supporting
blue screens

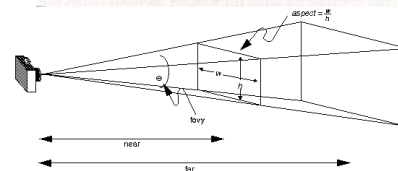
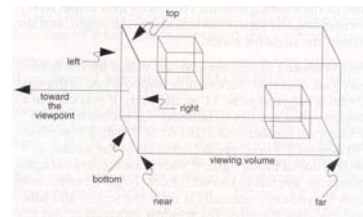
Camera Calibration

- Matching virtual camera to real camera
 - Internal parameter = projection matrix
 - External parameter = camera pose = model-view transform



Camera Calibration (continued)

- Standard Viewpoint Nodes
 - OrthoViewpoint
 - Orthographic projection
 - fieldOfView in min-max box
 - Viewpoint
 - Perspective projection
 - fieldOfView in radian



- Viewpoint node for MR visualization proposed
 - Directly assigning projection matrices
 - Assigning values from LiveCamera
 - Easily supports tracking information
 - Position, orientation field
 - Defined in X3DViewpointNode abstract type

Camera Calibration (continued)

- LiveViewpoint

```
LiveViewpoint : X3DViewpointNode{  
  SFMatrix4f      [in]      projmat  
  SFVec3f         [in,out]   position  
  SFRotation      [in,out]   orientation  
  SFNode          [in,out]   liveCamera  
}
```

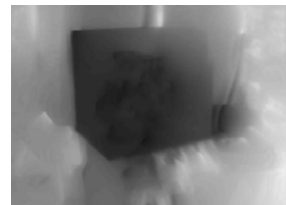
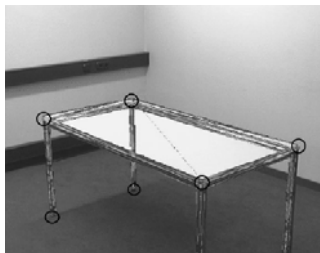
```
<Scene>  
  <LiveCamera DEF='USBCam1' source='dev#'/>  
  <LiveViewpoint liveCamera='USBCam1'/>  
  <Shape> ... </Shape>  
</Scene>
```

Or, using routes...

```
<Scene>  
  <LiveCamera DEF='USBCam1' source='dev#'/>  
  <LiveViewpoint DEF='MRView'/>  
  <Shape> ... </Shape>  
  <ROUTE fromNode='USBCam1' fromField='projmat'  
        toNode='MRView' toField='projmat'/>  
  <ROUTE fromNode='Tracker' fromField='position'  
        toNode='MRView' toField='projmat'/>  
  <ROUTE fromNode='Tracker' fromField='orientation'  
        toNode='MRView' toField='projmat'/>  
</Scene>
```

Correct Occlusions

- Ghost objects
- Live depth image (from stereo vision)



[D. Breen, Calif. Inst. of Tech / ECRC, 1996]

Correct Occlusions (continued)

- Ghost object flag as a field of Shape (or Group) node

```
<Scene>
  <Shape>
    <Appearance>
      <Material/>
    </Appearance>
    <IndexedFaceSet ccw='false' coordIndex='0 1 2 ... 15 16'>
      <Coordinate point='2.00 0.6 0.00 ... 2.00 0.6 0.00'/>
    </IndexedFaceSet>
  </Shape>
</Scene>
```

```
<Scene>
  <Shape isGhost='true'>
    <Appearance>
      <Material/>
    </Appearance>
    <IndexedFaceSet ccw='false' coordIndex='0 1 2 ... 15 16'>
      <Coordinate point='2.00 0.6 0.00 ... 2.00 0.6 0.00'/>
    </IndexedFaceSet>
  </Shape>
</Scene>
```

Correct Occlusions (continued)

- Live depth image
 - Depth cameras
 - Same as a LiveCamera, except provided images represent depth values, not color/intensity

```
<Scene>
  <Background groundAngle='1.309 1.571'
    groundColor='0.1 0.1 0 0.4 0.25 0.2 0.6 0.6 0.6'
    skyAngle='1.309 1.571'
    skyColor='0 0.2 0.7 0 0.5 1 1 1 1'
    backUrl='mountns.png'
    frontUrl='mountns.png'
    leftUrl='mountns.png'
    rightUrl='mountns.png'/>
</Scene>
```

```
<Scene>
  <LiveCamera DEF='USBCam1' source='dev#'/>
  <LiveCamera DEF='DepthCam1' source='dev#'/>
  <Background liveSource='USBCam1'
    depthSource='DepthCam1'/>
</Scene>
```

Summary

- Live video integration
 - Live video camera support
 - LiveCamera node proposed
 - Background
 - Add fields to Background node + route with LiveCamera
 - Defining a new node could be also an alternative (e.g., LiveBackground node)
 - Texture
 - Add fields to MovieTexture node + route with LiveCamera
- Camera calibration
 - Projection matrix
 - LiveViewpoint node proposed + route with LiveCamera
 - Lens distortion
 - Let LiveCamera provide distortion corrected information
- Correct occlusions
 - Ghost objects
 - Add a flag field to Shape/Group nodes
 - Live depth image
 - Add fields to Background node + route with LiveCamera

Future work

- Proof of concept implementation
- Tracking supports for registration and interaction
 - Integration of AR software libraries into X3D browsers/viewers
 - Ex. ARToolkit, ARTag, BazAR etc.
 - Proposed LiveCamera node only provides world coordinate
 - Local coordinates of multiple physical objects not considered yet
(Must be resolved to support interactions in MR environments)
- Shadows, Reflections & Refractions
 - Connection with projective texture mapping standards
 - New work item with environmental light maps
 - Environmental map/texturing + Shaders

Thank you!

Q & A