

Web3D Teck Talk
@ SIGGRAPH Asia 2010

Supporting Mixed & Augmented Reality Visualization in X3D

December 16, 2010

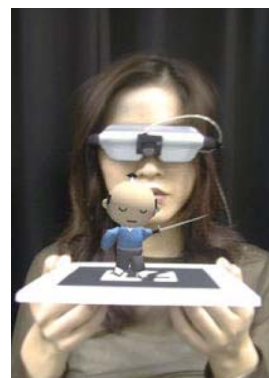
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Augmented Reality

- 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



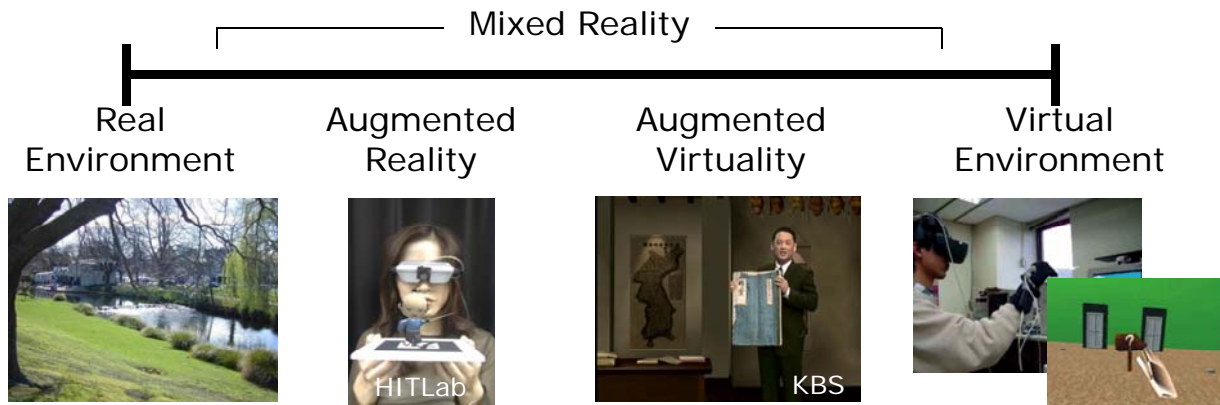
STAR System
[HRL Laboratories, 1998]



ARToolkit
[HITLab, Univ. of Washington, 1999]

Mixed Reality

- What is MR (Mixed Reality) ?



[Paul Milgram's Reality-Virtuality Continuum (1994)]

AR/MR Applications on the Web



AR Encyclopedia [metaio.com]



Volvo Ocean Race Promotion, 2008



Smart Grid Promotion GE, 2009



BMW Z4 Testrive Promotion, 2009



3D Experience Cerial Box, 2009 [Dassault Systemes]



Ray-Ban virtual mirror promotion, 2009 [FittingBox]

X3DOM AR

- X3DOM
 - HTML5 – WebGL
 - J. Behr, Fraunhofer
- FLARToolkit
 - Requires Flash Plug-in
 - Flash version of AR Toolkit
- Layers X3D scene on top of Flash viewport
- A good platform for experimenting and implementing AR/MR functions as standards
 - Users might benefit more if those functions provided by FLARToolkit becomes a standard in X3D, so that they would not need to handle repetitive wiring between flash and X3D.



Making X3D become MR capable

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

Live Video Support

- Fraunhofer + Korean Chapter

- CameraSensor: X3DDirectSensorNode {
 SFImage [out] value
 SFBool [out] on FALSE
 SFMatrix4f [out] projmat "1 0 0 0 ... "
 SFBool [out] tracking FALSE
 SFVec3f [out] position
 SFRotation [out] orientation
}

MovieTexture

- An Alternative way to CameraSensor

- Making MovieTexture user reconfigurable
- No change in syntax of X3D
- Add a standard behavior of MovieTexture to
 - Ask user if no source is declared
 - A dialog box presented to choose a movie file or a camera hardware

```
...  
<Appearance>  
  <MovieTexture loop='true' url='wrlpool.mpg'/>  
</Appearance>  
...
```

```
...  
<Appearance>  
  <MovieTexture loop='true' url=''/>  
</Appearance>  
...
```

Tracking

- Sensor based Tracking
 - Ultrasonic, Electromagnetic, Mechanical, Optical motion capture
- Computer Vision based Tracking
 - ARToolkit (HITLab), ARtag (Canadian NRC), BazAR (EPFL)



[ARToolkit, HITLab]



[ARtag, CNRC]



[BazAR, EPFL]

Registration & Real-time interactivity (cont'd)

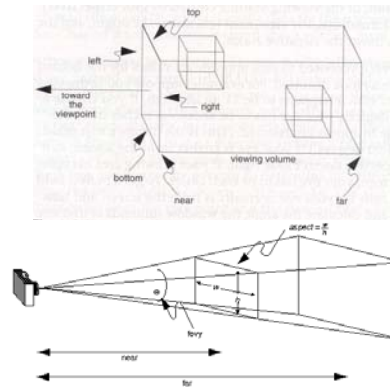
- Tracking methods
 - Too many/various to be standardized...
 - Delegation to browser/viewer implementation
 - Browser decides (or provides an interface to choose) which tracking methods/devices to use
 - Tracking technology in use is hidden, and only the tracking results are provided into X3D scene
 - X3D only provides interfaces to the tracking results
 - X3D authors do not have to worry about the hardware system setup in run-time

```
CameraSensor: X3DDirectSensorNode {
  SFImage      [in, out] value
  SFBool       []      out      FALSE
  SFMatrix4f   [out]   projmat  "1 0 0 0 ..."
  SFBool       [out]   tracking  FALSE
  SFVec3f      [out]   position
  SFRotation   [out]   orientation
}
```

Camera Calibration

- Standard Viewpoint Nodes

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



- Viewpoint node for MR visualization needs ...

- Directly assigning projection matrices
 - Assigning values from LiveCamera
- Easily support tracking information
 - Position, orientation field
 - Defined in X3DViewpointNode abstract type

Camera Calibration

- MatrixViewpoint

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

```
<Scene>
  <CameraSensor DEF='USBCam1'/>
  <MatrixViewpoint liveCamera='USBCam1'/>
  <Shape> ... </Shape>
</Scene>
```

Or, using routes...

```
<Scene>
  <CameraSensor DEF='USBCam1'/>
  <MatrixViewpoint 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>
```


Video on the Background

■ Current 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>
```

■ Extending the Background Node

```
...
<Live Camera DEF='cam' />
<Background DEF='bg' image="" />
  <ROUTE fromNode='cam' fromField='image' toNode='bg' toField='image' />
...
```

■ Or Adding a New Node

```
...
<LiveCamera DEF='USBCam1' />
<MovieBackground liveSource='USBCam1' />
...
```

Correct Occlusions

■ Problem of depth information of the real world

- Masking - Ghost object rendering
 - Multi-pass rendering
 - Render ghost objects and clear color buffer (leaving depth buffer)
 - Render live video background without depth value/testing
 - Render virtual objects
 - Simply rendering ghost objects with alpha-materials does not provide correct results
 - In this case, virtual objects behind the ghost object occludes the real object (rendered as a background)
- Depth image (e.g. stereo image matching)
- Others (e.g. skin color, chroma keying)



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

Depth Image

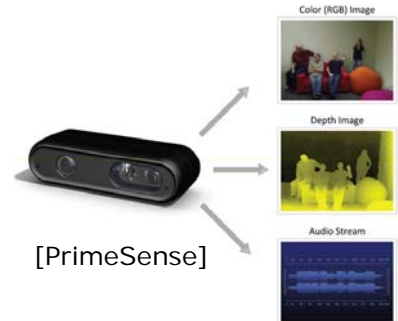
- Depth Camera
 - Pixel = rgb**d**
 - Got popular with MS Kinect
 - 3DV, Canesta, Optrima, PrimeSense ...

- Supporting Depth image in X3D
 - SFImage
 - MovieBackground
 - MovieTexture

- Applications
 - Z-keying
 - Relief Texture Mapping



[Microsoft Kinect]



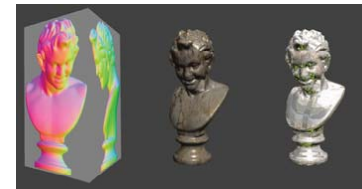
[PrimeSense]



[Wikipedia]



[Z-key, CMU]



[NVIDIA Cg Tutorial]

Chroma Keying

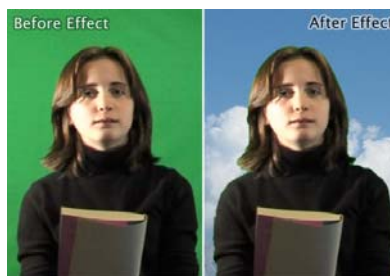
- Popular in broadcasting (Virtual Studios)
- Making specific colored pixels transparent

```

<Scene>
  <Shape>
    <Appearance>
      <MovieTexture src='...' keyColor='0 1 0' />
    </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>
    
```



[KBS, History Special]



[Kudlian Software]

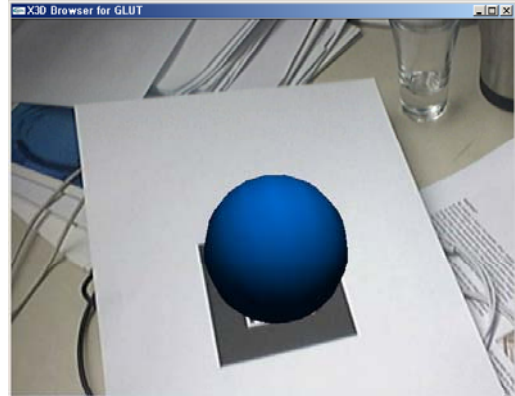
All together

```
...
<Scene>
  <CameraSensor DEF='cam' />

  <Background DEF='bg' />
  <ROUTE fromNode='cam' fromField='image' toNode='bg' toField='image' />

  <MatrixViewpoint cameraSensor='cam' />

  <Transform translation="0 0 40">
    <Shape>
      <Appearance>
        <Material diffuseColor='0 0.5 1' />
      </Appearance>
      <Sphere radius="40" />
    </Shape>
  </Transform>
</Scene>
...
```



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Lots of things to do @ AR WG

(coming up early 2011)

Please join us!
You are more than welcome!

Thank you!

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