Augmented and Mixed Reality BoF @ SIGGRAPH2011

Supporting Mixed Reality Visualization in Web3D Standard

August 11, 2011

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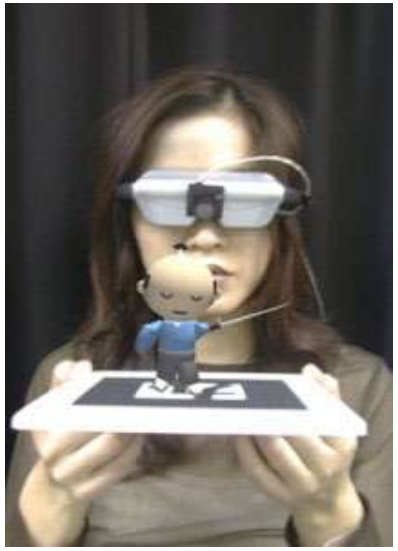
Augmented Reality

- 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

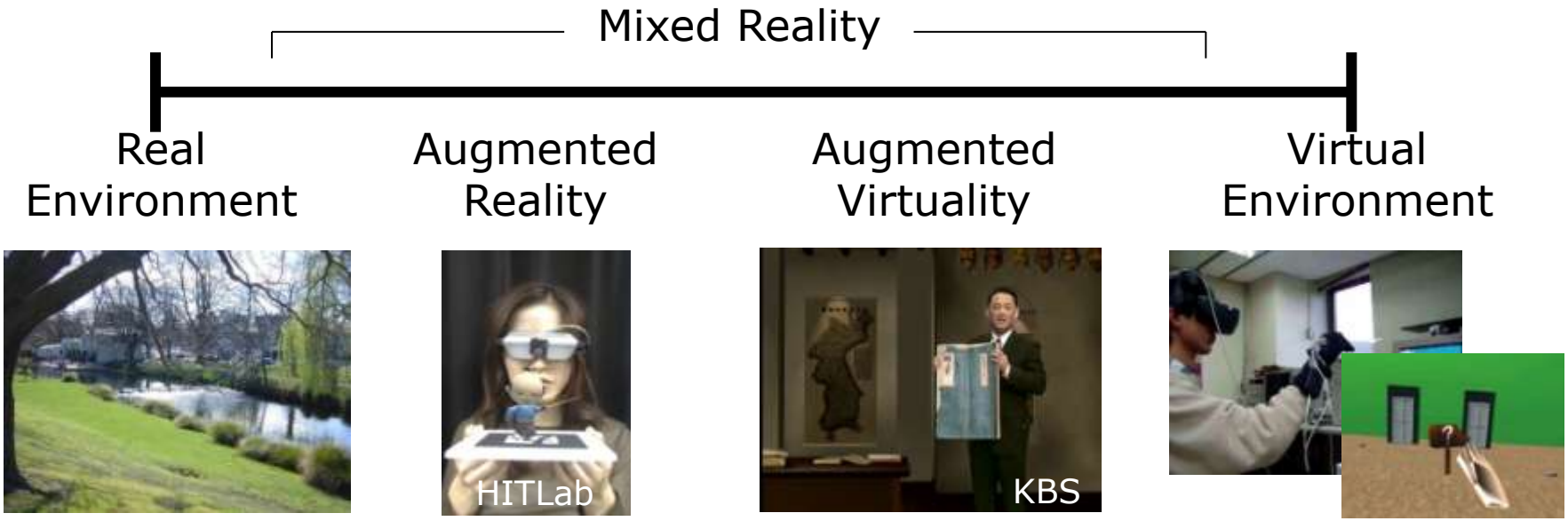
STAR System
[HRL Laboratories, 1998]



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

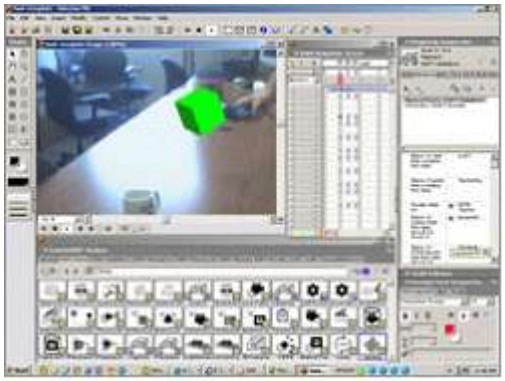
Smart Grid Promotion
GE, 2009

BMW Z4 Testrive Promotion,
2009

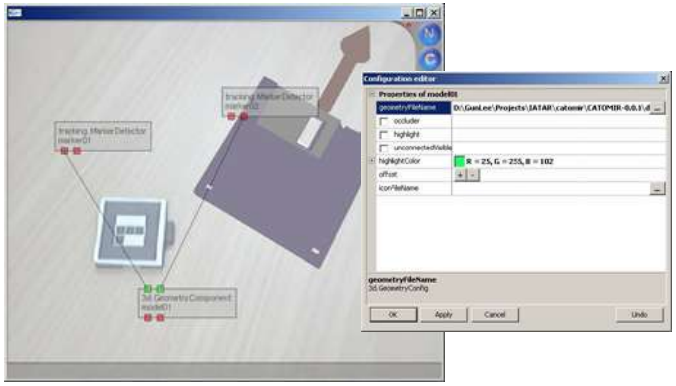
3D Experience Cerial Box,
2009 [Dassault Systemes]

Ray-Ban virtual mirror promotion,
2009 [FittingBox]

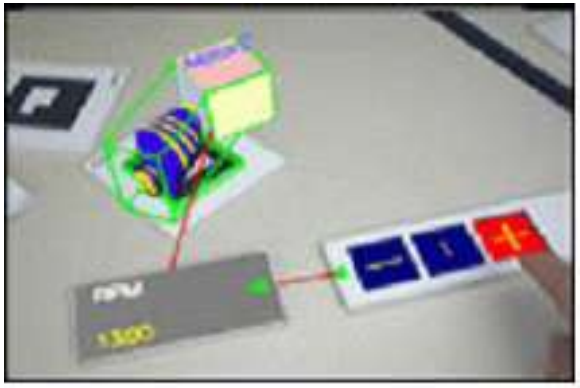
AR/MR Authoring Tools



DART
[Georgia Inst. of Tech., 2002]



Catomir
[AMIRE Project, 2004]



Immersive Authoring
[POSTECH / HIT Lab NZ, 2004]

ARtalet
[CTI/GIST, 2007]

BuildAR
[HIT Lab NZ, 2008]

UnifEye Design
[MetaIO, 2009]

AR/MR Contents

Standard file/content format?

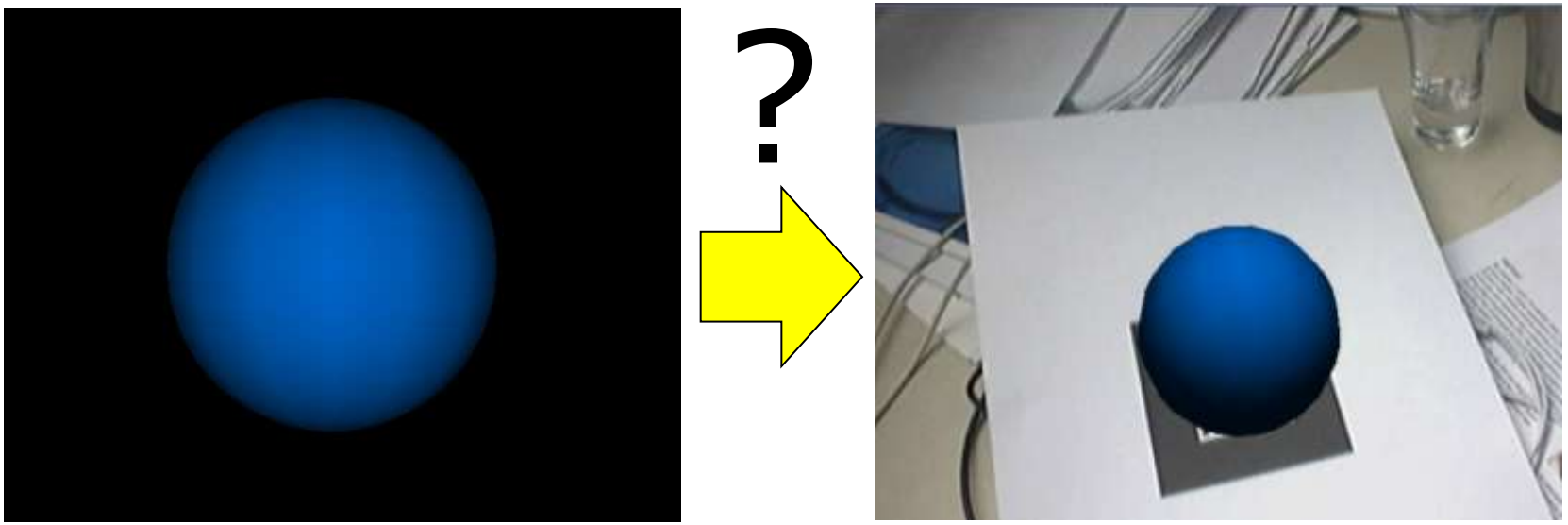
X3D

- Extensible 3D graphics
- ISO Certified Standard
- Royalty free open standard
- Developed by Web 3D Consortium – www.web3d.org
- Originated from VRML, now in XML

```
<?xml version="1.0" encoding="utf-8"?>
<!DOCTYPE X3D PUBLIC "ISO//Web3D//DTD X3D 3.0//EN"
"http://www.web3d.org/specifications/x3d-3.0.dtd">

<X3D version='3.0' profile='Interchange'>
<Scene>
    <Transform translation='-2.4 0.2 1.0' rotation='0.0 0.707 0.707 0.9'>
      <Shape>
        <Sphere radius='2.3'/>
        <Appearance>
          <Material diffuseColor='0.0 0.5 1.0'/>
        </Appearance>
      </Shape>
    </Transform>
</Scene>
</X3D>
```

Extending X3D to be AR/MR capable!



Requirements of X3D to be AR/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
  - Static - Relationship between real and virtual spaces
  - Dynamic - Tracking user's viewpoint
- Real-time Interactivity
  - Tracking (users & other real world objects)

Adding real world view

- Camera sensor (on the browser device)

```
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
    }
```

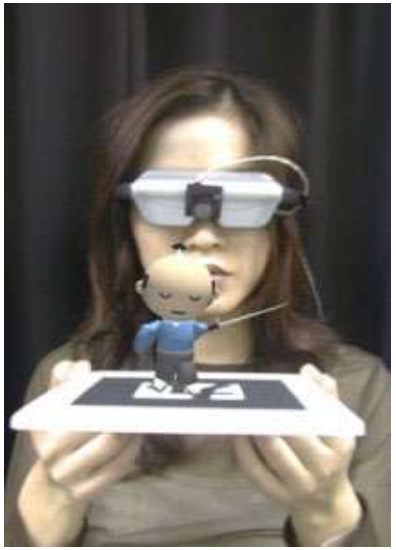
- Local live video stream background and texture

```
…
<CameraSensor DEF=‘cam’/>
<ImageBackground DEF=‘bg’ image=‘’/>
 <ROUTE fromNode=‘cam' fromField=‘image‘ toNode=‘bg' toField=‘image'/>
…
```

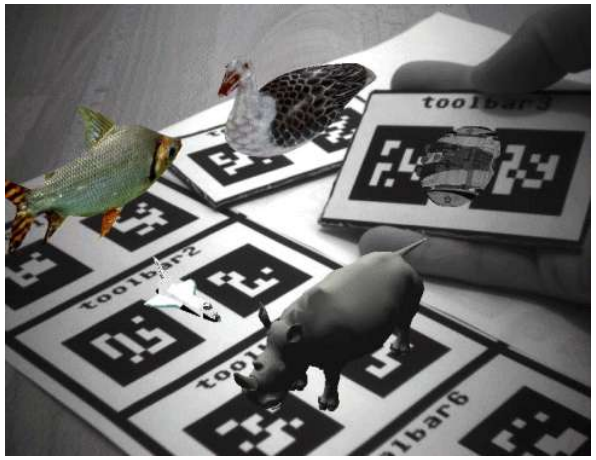
```
…
<Appearance>
     <MovieTexture loop='true'   src=‘cam'/>
</Appearance>
…
```

Tracking

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



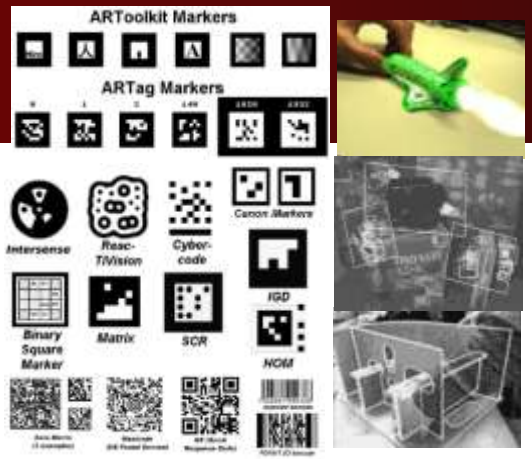
[ARToolkit, HITLab]



[ARTag, CNRC]

[BazAR, EPFL]

Tracking (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/support
    - 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

```
TrackingSensor:X3DDirectSensorNode {
   SFVec3f          [out]     position
   SFRotation       [out]     orientation
}
```

Camera Calibration

- Standard Viewpoint Nodes
  - OrthoViewpoint – Orthogonal projection
  - Viewpoint – Perspective projection

- Viewpoint node for MR visualization needs ...
  - Directly assigning projection matrices
    - Assigning values from LiveCamera

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

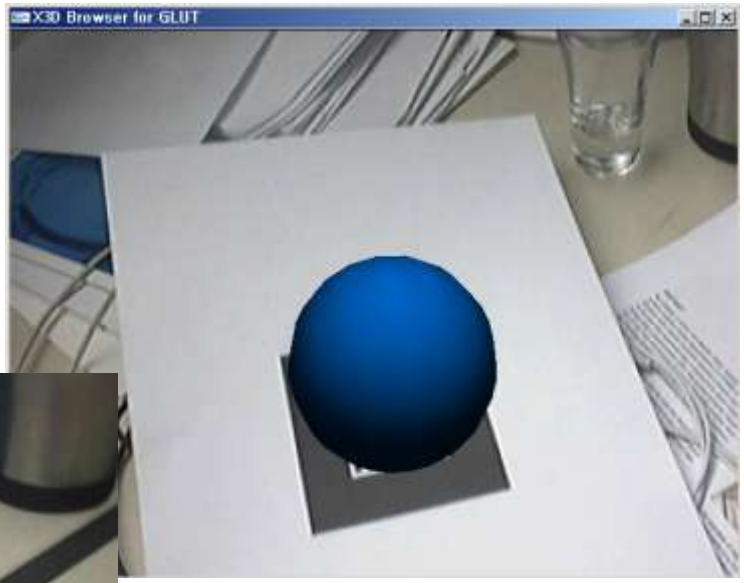
All together – X3D might look like ...

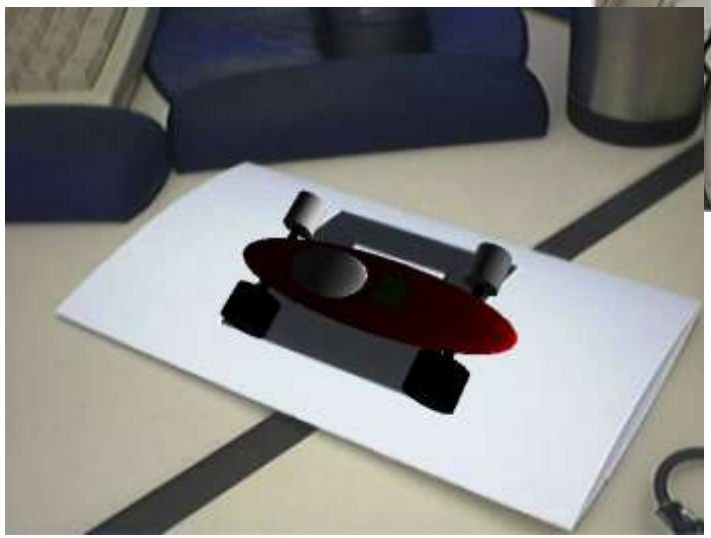
```
...
<Scene>
    <CameraSensor DEF=‘cam’/>

    <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>
...
```



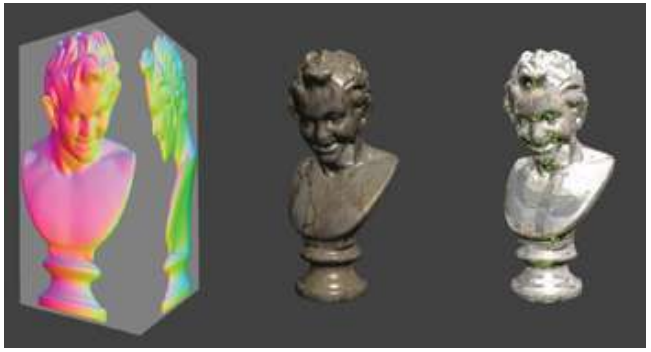


Other Visualization Topics

- Correct occlusions and Augmented Virtuality
  - Masking - Ghost object rendering
  - Depth image (e.g. stereo image matching, depth camera)
    - Pixel = rgbd
    - Got popular with MS Kinect
    - Support Depth image in X3D nodes (SFImage, MovieBackground, MovieTexture)
  - Heuristics (chroma keying with skin color)
    - Add KeyColor field to MovieTexture

Depth Image
[Wikipedia]

Masking [ETRI]



Relief Texture
[NVIDIA Cg Tutorial]

Chroma Keying / Augmented Virtuality
[Kudlian Software]

AR WG @ Web3D

- Focuses on utilizing and extending X3D capabilities to support augmented reality (AR) and mixed reality (MR) applications.
  - Started as a SIG on AR initiatives in July 2009
  - Became a working group in June 2011
- Goals
  - Collect requirements and describe typical use cases for using X3D in AR/MR applications
  - Produce and propose X3D components for AR/MR scenes and applications
  - Produce sample AR/MR applications using X3D to demonstrate how this functionality can work correctly
- Regular teleconferencing meeting
  - Monthly (3rd Wednesday) 10am CEDT, 5pm KST, 1am PDT

Lots of things to do @ Web3D AR WG

Please join us!
You are more than welcome!

Thank you!

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