Supporting Mixed Reality Visualization in X3D

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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]
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 Systèmes]

Ray-Ban virtual mirror promotion, 2009 [FittingBox]
AR Application with X3DOM

- **X3DOM**
  - HTML5 – WebGL
  - J. Behr, Fraunhofer IGD
- **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.
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)
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
}
Video on the Background

- **Current Background Nodes**
  - Describes 3D background that changes according to the viewpoint navigation
  - For AR applications, we need to make video on the background independent from the viewpoint navigation

- **ImageBackground Node**

```xml
... 
<CameraSensor DEF='cam'/>
<ImageBackground DEF='bg' image=''/>
<ROUTE fromNode='cam' fromField='image' toNode='bg' toField='image'/>
... 
```
MovieTexture / MovieBackground
– An Alternative way to CameraSensor

- Making MovieTexture user reconfigurable
- No big change to current X3D spec, no routing
- Add a standard behavior of MovieTexture to
  - Ask user to choose the video source (file or camera) if url field is empty (or specific token is used)

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

...
  <MovieBackground url=""/>
...
```
Tracking

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

- Tracking methods
  - Too many/various to be standardized...
  - Leave to browser implementation, X3D only provides interfaces to the tracking results
    - Browser decides (or provides an interface to choose) which tracking methods/devices to use/support
    - Tracking technology in use is hidden to X3D scene, and only the tracking results are provided into X3D scene
    - 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**
    - 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>
```
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>
...
Looking forward to...

- Correct occlusions and Augmented Virtuality
  - Masking - Ghost object rendering
  - Depth image (e.g. stereo image matching, depth camera)
    - Pixel = rgb\textit{d}
    - 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]
Looking forward to...

- OpenSceneGraph (www.openscenegraph.org)
  - C++ based scene graph library
  - Large user community
  - Open source, commercial friendly license

- osgART
  - AR plug-in to OSG
  - Different tracking technologies as plug-ins

- X3D support is missing !?
AR WG

- Started up and running since June 2011
- Active Members:
  - Gun Lee (HIT Lab NZ)
  - Gerard J. Kim (Korea Univ.)
  - Yvonne Jung, Sabine Webel, Johannes Behr (Fraunhofer IGD)
  - Oliver Neubauer (Bitmanagement)

- Slow, but steady
- Looking forward to gain more speed with more participants

- Current tasks
  - Requirement and use cases
  - Comparing and merging proposals
Lots of things to do @ AR WG

Please join us!
You are more than welcome!

Thank you!

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