Supporting Mixed Reality Visualization in Web3D Standard

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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)?
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]
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
<?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)
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

```plaintext
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]
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 teleconference 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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