HMD based VR Service Framework

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What is Virtual Reality?

Making an electronic world seem real and interactive

• Not static 3D image
• Not movies
• Moving within the 3D world
• Manipulating objects in the 3D world
Type of VR Experiences

- **Immersive Spaces**
  - 360° Panorama image/Video
  - High visual quality
  - Limited interactivity
    - Changing viewpoint orientation
  - User can turn head to see different views
  - Fixed Position

- **Immersive Experiences**
  - 3D graphics
    - Lower visual quality
  - High interactivity
    - Movement in space
  - Interact with virtual objects
Where 360° VR Walking Tour can apply?

- Virtual Map (University Campus, Hospital, Company, Factory...)
- Visiting Place (Park, Resort, Mountain, Temple...)
- Business Place (Hotel, Restaurant, bars, ...)
- More effective than Streetview
  - Add more information
  - Custom
  - Own system
  - Own website
Computer based Vs. Mobile VR

Computer based VR setup

- Computer
- Position sensor
- Head mounted display (HMD)

Mobile based VR setup

- VR mount
- Smartphone
- Head mounted display (HMD)
VR hardware explosion

- Increasing of Virtual reality hardware
- Affordable stereoscopic displays
- Head Mounted Display
- Motion tracking
- Head tracking

VR input devices

VR HMD devices
PC HMDs

- PC HMDs refer to Desktop peripheral acts as external monitor
- Provide deepest, most immersive VR
- Position and orientation tracking
- Tethered – one or more cables connect to computer such as camera for position tracking

Oculus Rift

HTC VIVE
Mobile HMDs

- Custom Android build/ Oculus mobile SDK
- Orientation tracking only
- Support for S6 coming – Samsung Gear VR
- Support for LG G5 – LG VR
- 110 diagonal FOV – Gear VR
- 1000hz refresh rate – Gear VR

Samsung Gear VR

LG VR
Drop-in phone viewers

- Open specification for mobile VR
- Orientation tracking only
- Standard Android, iOS support, using simple stereo rendering and accelerometer tracking
- Just add SmartPhone
- 90 degree FOV – Cardboard
- 200hz refresh rate

Google Cardboard

VR BOX
HMD VR service using X3D

- Stereo Image
- 360 Images
- 3D Models

Control Devices

- Send/Receive/See an message
- Send/Receive/See a received video
- Phone Call
- Text Typing
X3D VR walking tour

HMD VR Service Framework based on X3D

X3D

HMD VR Service Framework

- Head Tracking
- Positional Tracking
- Stereoscopic 3D
- Spatial 3D Sound
- Wide FOV
- Orientation Tracking

SDK

Gear VR
Google Cardboard
HTC VIVE
LG 360 VR
Oculus Rift
Sony PS VR
MS Hololens
HMD VR service Issues using X3D

- Interaction of X3D content and HMD devices
- Fisheye lens
- Display 4K (2,024 x 2,200) pixels
- A 90Hz refresh rate and 100 nits brightness
- Latency
- Bandwidth
- Seamless message services through smartphones
Interaction of X3D Content and HDM devices

**Image generating**: One of the most time consuming tasks in Virtual Reality is generation of 360° images, 3D Objects and 3D world.

**Stereo Vision**: Accomplished by creating two different images of the world once for each eye.

**Manipulation & Control Devices**: One key element for interaction to the virtual world that is tracking the position of real world objects such as head tracking, side-by-side stereo rendering, spatial audio rendering, detecting user inputs such as the trigger.
Stereoscopic vision is the normal vision humans and (most) animals have — the perception of two slightly differing images (one from each eye) as a single image. This results in depth perception, helping us to see the world in glorious 3D.
 POSITION AND ORIENTATION

The position sensor detects information concerning the HMD and constantly outputs it.

**Position**: The position of the HMD along three axes in a 3D coordinate space. x is to the left and right, y is up and down, and z is towards and away from the position sensor.

**Orientation**: The rotation of the HMD around three axes in a 3D coordinate space. Pitch is rotation around the x axis, yaw is rotation around the y axis, and roll is rotation around the z axis.
The field of view (FOV) is the area that each of the user’s eyes can reasonably be expected to see.

✓ upDegrees: The number of degrees upwards that the field of view extends in.
✓ rightDegrees: The number of degrees to the right that the field of view extends in.
✓ downDegrees: The number of degrees downwards that the field of view extends in.
✓ leftDegrees: The number of degrees to the left that the field of view extends in.
✓ zNear: The distance from the middle of the user’s head to the start of the visible FOV.
✓ zFar: The distance from the middle of the user’s head to the end of the visible FOV.
## Specification of HMD Devices

<table>
<thead>
<tr>
<th>Category</th>
<th>Gear VR</th>
<th>Oculus Rift</th>
<th>LG 360 VR</th>
<th>HTC VIVE</th>
<th>Sony PS VR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Display</td>
<td>2560x1440</td>
<td>2160 x 1200</td>
<td>1.88&quot; IPS LCD x 2 EA, 920 x 720 per Eye, 639 ppi Real RGB</td>
<td>2560x1200</td>
<td>1920 x 1080 960x1080 per eye OLED</td>
</tr>
<tr>
<td></td>
<td>1280 x 1440 per eye</td>
<td>1080 x 1200 per eye OLED</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Super AMOLED</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Refresh rate</td>
<td>60 Hz</td>
<td>90 Hz</td>
<td>60 Hz</td>
<td>90 Hz</td>
<td>120 Hz, 90 Hz</td>
</tr>
<tr>
<td>Sensors</td>
<td>Accelerator, gyrometer, geomagnetic, proximity</td>
<td>Accelerometer, gyroscope, magnetometer, 360-degree positional tracking</td>
<td>6-axis (Gyro &amp; Accelerometer) Proximity Sensor</td>
<td>Accelerometer, gyroscope, laser position sensor, front-facing camera</td>
<td>360 degree tracking, 9 LEDs</td>
</tr>
<tr>
<td>Field of view</td>
<td>96 degrees</td>
<td>110 degrees</td>
<td>Horizontal FOV (field-of-view) 80° lens</td>
<td>110 degrees</td>
<td>100 degrees</td>
</tr>
<tr>
<td>Controller</td>
<td>Bluetooth controller</td>
<td>Oculus Touch, Xbox One controller</td>
<td>G5 as handheld remote control</td>
<td>Vive Controllers, SteamVR controller, any PC-compatible gamepad</td>
<td>Sony DUALSHOCK 4 controller or PlayStation Move</td>
</tr>
<tr>
<td>Tracking area</td>
<td>Fixed position</td>
<td>5 x 11 feet</td>
<td>Fixed position</td>
<td>15 x 15 feet</td>
<td>10 x 10 feet</td>
</tr>
<tr>
<td>Minimum hardware requirements</td>
<td>Samsung Galaxy Note 5, Galaxy S6 series, or Galaxy S7 series</td>
<td>NVIDIA GeForce GTX 970 or AMD Radeon R9 290 GPU, Intel Core i5-4590 CPU, 8GB RAM, HDMI 1.3, 2x USB 3.0</td>
<td>LG G5</td>
<td>NVIDIA GeForce GTX 970 or AMD Radeon R9 290 GPU, Intel Core i5-4590 CPU, 4GB RAM, HDMI 1.3, USB 2.0</td>
<td>Sony Playstation 4</td>
</tr>
</tbody>
</table>
Considering X3D Node for HMD VR Services

X3D Nodes related to HMD VR services

- Displaying VR
- Sensing Data to control VR

X3D

- Viewpoint
- NavigationInfo
- Layering component
- Layout component
- KeySensor
- Route
- X3DSensorNode
- TouchSensor

WebVR

- VRDisplay
- VRLayer
- VREye
- VRFOV
- VRPos

Mapping
Considering X3D Node for HMD VR Services

Profiles: VR profile (HMD VR)
- Displaying VR (Stereo rendering)
- Sensing Data to control VR

X3DVRNode

X3DVRLayer
VRLayer provides layer for left and right eyes

X3DVRDisplay
VRDisplay checks the device information such as orientation, width and height.

X3DVRFov
VRFov provides the information of HMD field of views

X3DVREye
VREye sets and provides eye information.

X3DVRPose
VRPose represents a sensor’s state such as position, orientation

X3DVRContent
Grouping the X3D contents such as X3D external files, x3dom contents.

X3DMessanger (text & figure)

X3DMessager (Audio)

X3DMessager (Video)

X3DMessager (file)
Considering X3D Node for HMD VR Services

Hierarchies of X3DVR

- X3DChildNode
  - X3DVRNode
  - X3DVRLayer
  - X3DVRPose
  - X3DVRDisplay
  - X3DVREye
  - X3DVRFov
- X3DVRContent
- X3DMessenger
- X3DCapturer/X3DPureSensor
HMD VR service using X3D

- Stereo Image
- 360 Images
- 3D Models

Control Devices

- Send/Receive/See an message
- Send/Receive/See a received video
- Phone Call
- Text Typing
HMD VR Service based on Stereo Video

Left image  Right image

Fisheye Lens
Image Distortion

Texture images
360° VR Tour Development

Capturing spherical panorama photos with 360° camera devices

360° Photos

Creating a sphere and places the user at its center

Web framework for building virtual reality

Authoring tool for virtual reality walking tour

Generating Json

Stereo view of the virtual reality walking tour on a browser
Panorama images for visualizing 360 scene

- 360° VR Tour app is composed by a panorama (pano) image, cubic and spherical

- A panorama image allows you to see the image from every angle including above, below, behind and next to you, that’s the reason they are also called 360 images or spherical panoramas.
X3D Panorama image

- Cubic : Skybox mapping (Background) (6 images)
  : 3D provides panoramic background node for Universal media

- Equirectangular: Spherical mapping (360 image)  Size: 2048x2048
  : Sphere and Image Texture

Size: 5376x2688
Cubemaps are the other format of 360 panoramas. This format uses six images for the six faces of a cube that will fill the sphere around us. It’s also known as a skybox.
X3D Cubic panos

- In 2D layouts, the X-axis points to the right and the Y-axis points down, which means that the top left is (0, 0) and the bottom right will be the width and the height of the element at (width, height).
### X3D 360° image – cubic

- X3D provides panoramic background node for Universal

**Fields**

These are the X3D / X3DOM fields of this node. Values should usually be received / set as strings via DOM functions (i.e., using `setAttribute("myFieldName", "myFieldValue")` and `getAttribute("myFieldName")`).

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Default Value</th>
<th>Range</th>
<th>Inheritance</th>
<th>Standard</th>
<th>Description</th>
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<tbody>
<tr>
<td>backUrl</td>
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<td>[URI]</td>
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<tr>
<td>bind</td>
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<td>false</td>
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<td>3dom</td>
<td>Pushes/pops the node on/from the top of the bindable stack</td>
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<td>[URI]</td>
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<td>groundAngle</td>
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<tr>
<td>groundColor</td>
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<td>(0,0,0)</td>
<td>[0,1]</td>
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<td>3dom</td>
<td>Color of the ground</td>
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<tr>
<td>isActive</td>
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<tr>
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<td>X3D</td>
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<tr>
<td>skyAngle</td>
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<td>3dom</td>
<td>Angle of the sky</td>
</tr>
<tr>
<td>skyColor</td>
<td>MFColor</td>
<td>(0,0,0)</td>
<td>[0,1]</td>
<td>X3DBackgroundNode</td>
<td>3dom</td>
<td>Color of the sky</td>
</tr>
<tr>
<td>topUrl</td>
<td>MFString</td>
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<tr>
<td>transparency</td>
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<td>[0,1]</td>
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<td>3dom</td>
<td>Transparency of the background</td>
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</table>
X3D 360° image – cubic

```xml
<X3D showStat='false' showLog='false' style='...'>
  <Scene DEF='scene'>
    <Viewpoint position="0 0 4"></Viewpoint>
    <Background id='back1'>
      backUrl='"../img/cubic/pano_b.jpg"' bottomUrl='"../img/cubic/pano_d.jpg"
      frontUrl='"../img/cubic/pano_f.jpg"' leftUrl='"../img/cubic/pano_l.jpg"
      rightUrl='"../img/cubic/pano_r.jpg"' topUrl='"../img/cubic/pano_u.jpg"'></Background>
    <Transform>
      <Shape>
        <Appearance>
          <Material diffuseColor=".7 .7 .7" specularColor=".5 .5 .5" />
          <ComposedCubeMapTexture repeatS="false" repeatT="false">
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            <ImageTexture containerField="bottom" url='"../img/cubic/pano_d.jpg"'/>
            <ImageTexture containerField="front" url='"../img/cubic/pano_f.jpg"'/>
            <ImageTexture containerField="left" url='"../img/cubic/pano_l.jpg"'/>
            <ImageTexture containerField="right" url='"../img/cubic/pano_r.jpg"'/>
            <ImageTexture containerField="top" url='"../img/cubic/pano_u.jpg"'/></ComposedCubeMapTexture>
        </Appearance>
        <Sphere solid="false"></Sphere>
      </Shape>
    </Transform>
  </Scene>
</X3D>
```
X3D 360° image – cubic

http://cgac.cbnu.ac.kr/vr/pano/cubemap.html
X3D Equirectangular panoramas

- An equirectangular pano consists of a single image with an aspect ratio of 2:1, meaning that the width must be twice the height.

Size: 5376x2688
Creating a sphere and using `imageTexture` to texture equirectangular image
X3D 360° image – equirectangular

http://cgac.cbnu.ac.kr/vr/pano/equirectangular.html
360 VR Tour – Navigation

- Move to the next scene
- Focus on the icon or click
- Show the next place’s name
360 VR Tour – Tooltips

- Information icon
- Image tooltip type (attribution, attributionUri, width, height)
360 VR Tour – Tooltips

- Textblock tooltip type (text, width, height)
360 VR Tour – Tooltips

- Video tooltip type (source, width, height)
Seamless Message Supporting Service through Phones

- Send/Receive/See an message
- Send/Receive/See a received video
- Phone Call
- Text Typing
- Transmission of files
Considering X3D Node for HMD VR Services

Profiles: VR profile (HMD VR)
- Displaying VR (Stereo rendering)
- Sensing Data to control VR

Grouping the X3D contents such as X3D external files, x3dom contents.

X3DVRCContent

X3DMessanger (text & figure)  X3DMessanger (Audio)  X3DMessanger (Video)  X3DMessanger (file)
Conclusion

- Render a VR scene based on X3D
- Interaction of X3D VR scene and HMD devices
- Provide seamless services while seeing X3D VR scene