Revisiting Virtual Reality Training using Modern Head Mounted Display and Game Engines

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Christian Michelsen Research (CMR)

- Founded by Christian Michelsen
  - Shipping magnate and first prime minister of Norway 1905.

- First independent research institute in Northern Europe.

- About 175 employees most of which have PhDs.

- Most of our funding comes from private industry.

- Markets: oil and gas, marine and maritime, renewable energy, space.

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VR Safety

• VR Safety Project started in 2004 funded by Statoil and Norsk Hydro.

• A virtual reality application for the oil and industry for enhancing safety through improved risk communication, interactive learning, and training.

• Specialized for gas leaks, fire, and explosion scenarios.
VR Setup

- 4.6m x 1.6m screen back projected by two Barco Galaxy NW-7 projectors.
- Stereo view achieved using active shutter glasses from Nvidia synchronized with an infrared signal.
- Positional and rotational tracking of the glasses achieved using iotracker software together with infrared cameras.
Results of VR Safety

• Creating a custom 3D engine was time consuming (and thus expensive) and tedious to maintain.

• A large screen display (or a multisided cave) is expensive.

• The overall hardware experience in 2004 was not really ideal for full VR immersion.

• For these reasons it’s been difficult to convince industry to fund this project further.
Results of VR Safety

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• The overall hardware experience in 2004 was not really ideal for full VR immersion.

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But the recent availability of affordable and advanced HMDs as well as 3D engines has created a new opportunity for affordable VR safety and training.
Head Mounted Displays

Three Developer kits/prototypes
- Oculus VR Rift
- Sony Project Morpheus
- HTC Vive

Each developer kit offers similar features including a wide field of view and six degrees of freedom. Commercial version of each HMD are expected in 2016.

One Consumer product
- Samsung Gear VR
The Oculus Rift HMD

VR technology company based in Irvine California. Bought by Facebook for 2 billion USD in 2014.

• DK2 (2014-)
  • One screen with a resolution of 1920x1080 (960x1080 per eye)
  • Six degrees of freedom: pitch, roll, yaw and positional tracking.
  • 90 degree horizontal FOV.
• Consumer version expect in Q1 2016
  • 360 degree positional tracking, integrated audio
  • Higher resolution with separate displays for each eye.
Sony Project Morpheus

- Primarily for the PlayStation 4 and PlayStation Vita.
- Available for select developers.
- We were not sure how to acquire one.
HTC Vive

- Coproduced by HTC and Valve Corporation.
- Two screens, one per eye, each with a resolution of 1080x1200.
- Available for select developers.
- We applied for one through Valve but did not receive a response.
Samsung Gear VR

- Built around a mobile phone and thus is more limited in computing and graphics capabilities.
- Only has three degrees of freedom (no positional tracking).
- Designed for mobile VR.
Oculus Rift DK2 Field of View

The FOV is more than 90 degrees horizontal (110 degrees diagonal)

The lenses used for the wide FOV create two distortions: a pincushion distortion and chromatic aberration. These are compensate by creating barrel distortion as a function of each primary color.
Chromatic Aberration
Game Rendering Engines

Unity 5
• Free personal license for entities earning less than 100,000 USD per year.
• Professional license is either 75 USD per month or 1500 USD as a one-time
  free per developer.
• Cannot be used for gambling related activities.

Unreal 4
• 5% royalty fee on revenue over 3000 USD per product per calendar year.
• Cannot be used for gambling, military with live combat, nuclear facilities,
  or in critical aircraft software.

CryTek CryEngine
• 9.90 USD or Euro per month subscription required
• The subscription based EULA limits it to games only (not even serious games).
Porting Geometry Models

The original industrial model for VR Safety came from a CAD design and was provided to us as an Open Scene Graph Binary file (IVE): 668 Mb, 5 million triangles.

Unity 5 and Unreal 4 both can import FilmBox (FBX) files. Unity 5 can also import Colladea (DAE) files among other formats.

- We converted the IVE files to DAE files as well as 3ds Max (3DS) files.
- Next, we used Blender to convert the DAE files and the 3DS files to FBX files.
- Unreal failed to import the FBX files from DAE or 3DS.
  - Unreal appears to be unsuitable for importing large CAD generated files.
Porting into Unity

- The FBX files imported into Unity but without smooth shading.
- The DAE files directly into Unity with the smooth shading.
- All textures failed to import but it was easy to reassign textures with the Unity editor.
- Several surfaces flickered due to overlapping surfaces.
- Collision detection was enabled by simply clicking a checkbox when importing the model.
- Navigation was a simple matter of importing an asset.
Visual Quality

VR Safety

Gas leak

Unity

- Shadows
- Trees
- Ocean
The Immersive Experience

- Compared to VR Safety those using the demonstration using the DK2 and Unity found it far more immersive.
- The lack of being able to see one’s arms reduced the immersive feeling.
- With shadows and animated ocean the frame rate could drop significantly.
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The biggest problem using the DK2 was motion sickness. After 30 minutes of use I had nausea for over one hour after ending the demonstration.
## VR Safety versus HMDs and Game Engines

### Large screen vs. HMD

<table>
<thead>
<tr>
<th></th>
<th>Large-screen VR</th>
<th>HMD VR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardware price</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Motion sickness</td>
<td>Low</td>
<td>Medium</td>
</tr>
<tr>
<td>Interdisciplinary</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

### Custom 3D engine vs. Game Engines

<table>
<thead>
<tr>
<th></th>
<th>VR Safety</th>
<th>Unity</th>
<th>Unreal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Importing large geometry</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Visual editor</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Rendering quality</td>
<td>-</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>Adding functionality</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Pricing scheme</td>
<td>In-house</td>
<td>Per dev. Licence</td>
<td>Per sale</td>
</tr>
</tbody>
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++ is better than + which is better than -
Conclusion

• VR Safety was too expensive due to the cost of the hardware and developing a custom 3D engine.

• The recent availability of affordable and powerful HMD devices along with inexpensive and advanced 3D game engines however creates a new opportunity for VR based training systems.

• Our experience using the DK2 and Unity 5 felt more immersive than with our custom hardware and software solution.

• The two main challenge with HMDs versus a cave are:
  • creating a collaborative experience (e.g. using a virtual avatar to visualize your arms and other people) and,
  • motion sickness.