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// Impact of Human Factors for Mixed Reality contents: /
# How to improve QoS and QoE? #

Dr. Jérôme Royan
Definitions
“The Virtual reality is a scientific and technical domain exploiting computing and **behavioral interfaces** in order to **simulate** in a **virtual world** the behavior of 3D entities that are **interacting** in **real time** with each other and with one or more users in a **pseudo-natural immersion** through **sensory-motor channels.**”

*French Virtual Reality Treatise*
AR systems having the following 3 characteristics:

- Combine real and virtual
- Interactive in Real Time
- Registered in 3D
- Special Effect
- Virtual Reality

Evolved Milgram continuum

Interactivity Level

- Full Interactive
- 6DoF
- 3DoF++
- 360°/3DoF
- Flat°/0DoF

Reality
Augmented Reality
Augmented Virtuality
Virtual Reality

360°/3DoF
3DoF++
6DoF
Full Interactive

Video player
3D rendering engine

Real Environment
Mixed Reality
Virtual Environment

360 video
360 animation video
Adobe VR 6DoF
8i Volumetric Video

2D movie
360 FX video
FX

Immersive Content
Human Factors & VR/AR
Motion Sickness

Visual / vestibular cues conflicts

Visual movement

Static posture
- Visual cortex
- Internal ear
- Cerebellum
- Area postrema
Visual / vestibular cues conflicts

› When does this happen?
  • Virtual and real acceleration are inconsistent
    - Real navigation space smaller than virtual space
    - Motion-to-photon latency > ~17ms

› Some solutions:
  - Head Movement Tracking
  - Rendering
  - Timewarp
  - VR Display
  - Motion-to-Photon Latency

Some solutions:
- Scale 1:1 (e.g. Job Simulator)
- Teleportation (e.g. Robo Recall)
- Self-perception (e.g. Nimble Sense)
- Static reference frame (e.g. Sony RIGS)
- Black filter (e.g. Ubisoft Eagle Flight)
- Peripheral Grid (e.g. Google Earth VR)

Smart VR content design
Peripheral field of view filters
Virtual Reality Sickness Evaluation

› Usual subjective method

› b<>com approach
  - Learning VR sickness level based on physiological signals

- Objective
- Automatic
- Continuous
- Non-intrusive
Convergence / Accommodation conflicts

VR Head Mounted Display

AR Head Mounted Display

Virtual accommodation distance

Point of Convergence

Convergence distance

Virtual Screen

Pure visual conflicts

VR Head Mounted Display

AR Head Mounted Display

Virtual accommodation distance

Point of Convergence

Convergence distance

Virtual Screen

Semi-transparent mirror

Micro display Lens

Convergence and potentially real accommodation distance

Diffusion : public

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What is ideal field of view and resolution?

Human Visual Acuity:
- 10/10 = 1 arc min = 1/60 degree
  - Pixels can be distinguished at 1/60° degree
- 150°x130° -> 9000x7800 pixels per eye
  - And perhaps more with radial distortion due to lenses

The ideal VR/AR HMD:
- **Field of view**: 2 x 150° x 130°
- **Resolution**: 2 x 9000 x 7800 pixels
- **Frequency**: at least 120Hz
- **Photon-To-Motion Latency**: < 17ms

Vertical field of view ~130°
Other issues

› Visual issues
  • Misalignment eye / lens / screen
    - Can change scale perception in VR
    - Hand-eye calibration required for good registration with AR HMD
  • Chromatic aberrations
  • Binocular rivalry

› Visual / Audio Consistency
  • Sound sources have to be well registered with visual objects that emit them

› Etc.
Technical Impact
360° Video streaming

- **Today**: HTC Vive, Oculus CV1
  - 360°, 2048 pixels
  - ~90°, ~512p
  - 360°, 1080 pixels
  - ~100°, ~300p

- **Future**: X2 (stereo)
  - 360°, ~21 600 pixels
  - ~150°, ~9000p
  - ~130°, ~7800p

**Region of Interest, foveal & zero-latency compression**
Future untethered HMD

- Perspectives to handle high-def untethered HMD
  - Foveal based compression
  - Very high wireless bandwidth

Video streaming technology

HMD side

- Head Movement
- VR Display
- Tracking
- Timewarp
- Zero latency Decoding

Computer Side

- Rendering
  - 2x9000x7800@120
  - Zero latency Encoding (ratio 1:4)
  - ~470Gbps
  - ~120Gbps
  - < ~17ms
Conclusion
Taking into account Human factors is the key to VR generalization.

The Production of comfortable 3D videos has been extremely, and will become a nightmare concerning immersive contents such as VR.

But it terms of user experience, it will be worth it!

360° Video will become more and more interactive.

### Conclusion

**Pro**
- Many contents
- Useful
- Good QoE

**Cons**
- Gadget
- Sickness
- Costly

Immersive content adoption
Merci / Thanks

/jerome.royan@b-com.com/