Research Advancements in Fidelity Enhanced Virtual Environments

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Outline

• Introduction
• Problem
• Justification
• Background
• Case studies
• Takeaways/conclusion
Introduction

• Fidelity plays an important role in virtual reality
• Although it may be perceived differently from user to user, it can increase or brake immersion, interactions, flow and presence
Introduction

“The conventionally held view of a Virtual Reality (VR) environment is one in which the participant observer is totally immersed in, and able to interact with, a completely synthetic world”

Introduction

• Visual feedback plays an important role in current virtual reality interactions

• It is also the sense that has obtained the most attention as a result of the evolution of graphics hardware and the desire of render more realistic computer scenes

• Fidelity, is associated to the level of realism and it plays an important role in the development of virtual scenarios

• From visual, audio, and haptics, to their articulation with the interaction mechanics, fidelity can be customized to elicit different responses and effects on users
About Fidelity

- Amount of realism (graphics example)
  - Low
    - Polygonal graphics
  - High
    - Photorealistic computer graphics
Is too much realism bad?

• It is a factor that depends on the scenario

• In medical education some procedures can be trained with low fidelity simulations given the focus on cognitive skills

• On the other hand, high fidelity simulations are most important when developing psychomotor skills that are transferrable to real life scenarios, such as high fidelity haptics training for surgery planning

• Depending on the skills and goals of the scenario, a blend of fidelity modes can provide different opportunities to develop skills
On how we perceive our environment

• We are comprised of a large collection of sensors and actuators
• Several systems are inspired on how we work, and try to mimic us or structures in the nature
• Very tough task
On how we perceive our environment

- Do we all see the same?
- Do we all feel the same? (I’m referring to the sense of touch)
- Do we hear the same?
- Do we perceive flavours the same?
Drawing

• Let’s say you want to draw something
• What would be the inputs, outputs, systems, sensors, and actuators involved,
• How that drawing might be perceived? .....
Problem

- Fidelity is dependent on technology advances
- Early flight simulators had people moving the mechanical contraption, they were later replaced by electro-mechanical actuators, sensors, hydraulics, and modern robotics
- Early flight simulators employed pre-recorded videos, that were later replaced by computer graphics, currently providing high realistic scenarios
- In terms of audio and haptics, advances have progressed at a different pace
- More specifically, haptics is still actively research towards developing consumer-level solutions that can improve feedback in comparison to the high-end equipment
Problem

- However, advances in computer graphics have been notorious in visual feedback and realism
Haptic Feedback

• Named thanks to the Greek root *HAPTHAI* that means “touch”
• These devices allow to pick up sensorial information in order to identify objects
• Along with audio and video gives more realism to the interaction
• Haptic systems are based on hand interaction, this because the hands have the most sensorial receptors in human body.
Modalities

• Touch Feedback
  - Provides information about surface, geometry, rugosity and temperature.
    - doesn’t resist contact
    - Objects can be trespassed

• Force Feedback
  - Provides information about surface, weight and inertia
    - Resist the contact and cannot be trespassed.
Requirements to design haptic systems

• Security and comfort
• Safe: the weight that the systems do must not harm the user.
• Portability: hardware must be light weighed and no invasive
Haptic Human System

• Haptic Sensing:
  - Skin has four kind of sensors:
    • Meissner Corpuscle: quick adaptation.
    • Merkel Discs: slow adaptation
    • Pacini Corpuscle: quick adaptation
    • Ruffini Corpuscle: slow adaptation
  - The quick adaptation sensors have a quick discharge so that a constant force does not feel
  - Slow adaptation sensors have a constant discharge while in contact
  - If the contact has a great variation, vibration or acceleration, quick adaptation sensors are used.
  - If the contact is constant, borders, force, static, slow adaptation sensors are used.
Motor-Sensorial Control

• Characteristics:
  - Fatigue capacity by a great force.
  - Sustained fatigue by force
  - Force tracking
  - Force control

• The finger’s strength depends of an action deliberated or by reflex, how the objects are taken, users gender, age and skills.
Rationale

https://www.forbes.com/sites/bernardmarr/2016/04/05/why-everyone-must-get-ready-for-4th-industrial-revolution/#3cb4e3633f90
At the center
We can take advantage of our body information
There are affordable approaches...

• 3D printing
• Open electronics
• More powerful mobile computing
• New developments
Alternatives

https://www.youtube.com/watch?v=eM2hydbs8d8

https://www.3ders.org/articles/20150728-engineer-creates-a-3d-printed-exoskeleton-spiderhand-for-stroke-victims.html

http://www.roboticstrends.com/article/eduexo_diy_kit_lets_you_build_exoskeletons/DIY%7C_Arduino


https://www.3dhub.com/talk/thread/3d-printed-exoskeleton-arms

https://www.3ders.org/articles/20150728-engineer-creates-a-3d-printed-exoskeleton-spiderhand-for-stroke-victims.html
Can we simplify interactions and tweak the fidelity?
Fidelity in Robotics and Medical Simulation

Roboticist Hiroshi Ishiguro and the android based on his likeness.

Showa University third generation dental robot

Laerdal Simulator
So....... Why high/lower fidelity matters?

• The level of detail and realism can help develop skills in many scenarios (e.g., medical, industry)

• Cognitive and psychomotor skills help develop decision making and capabilities to respond in diverse situations

• Given the cost on high-fidelity.... Can we tweak it to be compensated by adjusting multimodal cues?
Multimodal Interactions

• Sight-Touch-Hearing-Olfactory
• Convey realism
• One sensory system may affect the other
• Why? Conflicts between the cues
Case Studies

- Heart and eye examinations require extensive training (as do other medical procedures)
- These are routine examination procedures
- Cardiac auscultation allows diagnosing the heart and detect anomalies early
- The eye examination allows diagnosing the eye and helps identify associated disorders early
- Diseases found in time can make the difference between life and death in the case of the heart, and sight loss in the case of the eye
- Simulation is the standard for medical training.
Cardiac Auscultation

https://meded.ucsd.edu/clinicalmed/heart.htm

http://www.thinklabs.com/

www.blaufuss.org

http://www.laerdal.com/ca/harvey

http://www.laerdal.com/us/SimMan3G
Cardiac Auscultation

• Visual feedback
Cardiac Auscultation

3DOF Smartphone through accelerometer + gyro (Direct UI)

2DOF selfie stick

Screen

User

Cursor movements mapped into the screen

2 DOF

Mouse

3 DOF

Falcon

5 DOF or more

Other

Network Connectivity:
LAN Host
LAN client
LAN server

Virtual Patient

Auscultation areas:
Aortic
Mitral
Pulmonic
Tricuspid

Change between male and female patients

Virtual Camera

Camera pitch and yaw sliders

2DOF mobile device holder

Grip

CAD design

2DOF selfie stick
Cardiac Auscultation

[Images of virtual cardiac auscultation and VR experience]
Eye Examination

M82, M82A
EYE Examination Simulator
Eye Examination
Eye Examination

(a) Amplified ophthalmoscope lens.
(b) Sculpted eye model with interactable anatomical landmarks.
(c) Non-textured sculpted eye model.
(d) Navigation map and interactive anatomical landmarks (e.g., optic disc).
Virtual Drilling

USB - Bluetooth

3D printed custom drill

Arduino UNO

Novint Falcon haptics device
3 translational DOF

External view

Drill bit
Drill

Target drilling haptics interactive surface

Random drilling depth

Internal view

Introduction and explanation

Objective

Assessment

Your task is to drill through the wood at the marked point. You have to click the main button on the mouse grip to drill through. To start please press the space bar on the keyboard and when you finish press the space bar again.

"Press Space to Start"

Rate the Falcon relism in comparison to a real drill on scale from 1 to 7.
1 is low, 7 is high.

Continue
Takeaways

• Fidelity plays an important role in simulation and virtual reality as it can help develop different skills and shape experiences towards specific outcomes

• There are alternatives to high-end equipment that can help increase the install base of solutions that can be widely adopted, thus having a broader impact on the consumer-level population

• Technology is changing at a fast pace, open opportunities to conduct research in the fidelity and multimodal field

• However, hardware, software, and user variability, increase the difficulty of assessing the fidelity perception
Thank you!

Questions?

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