Haptic technologies for the Metaverse

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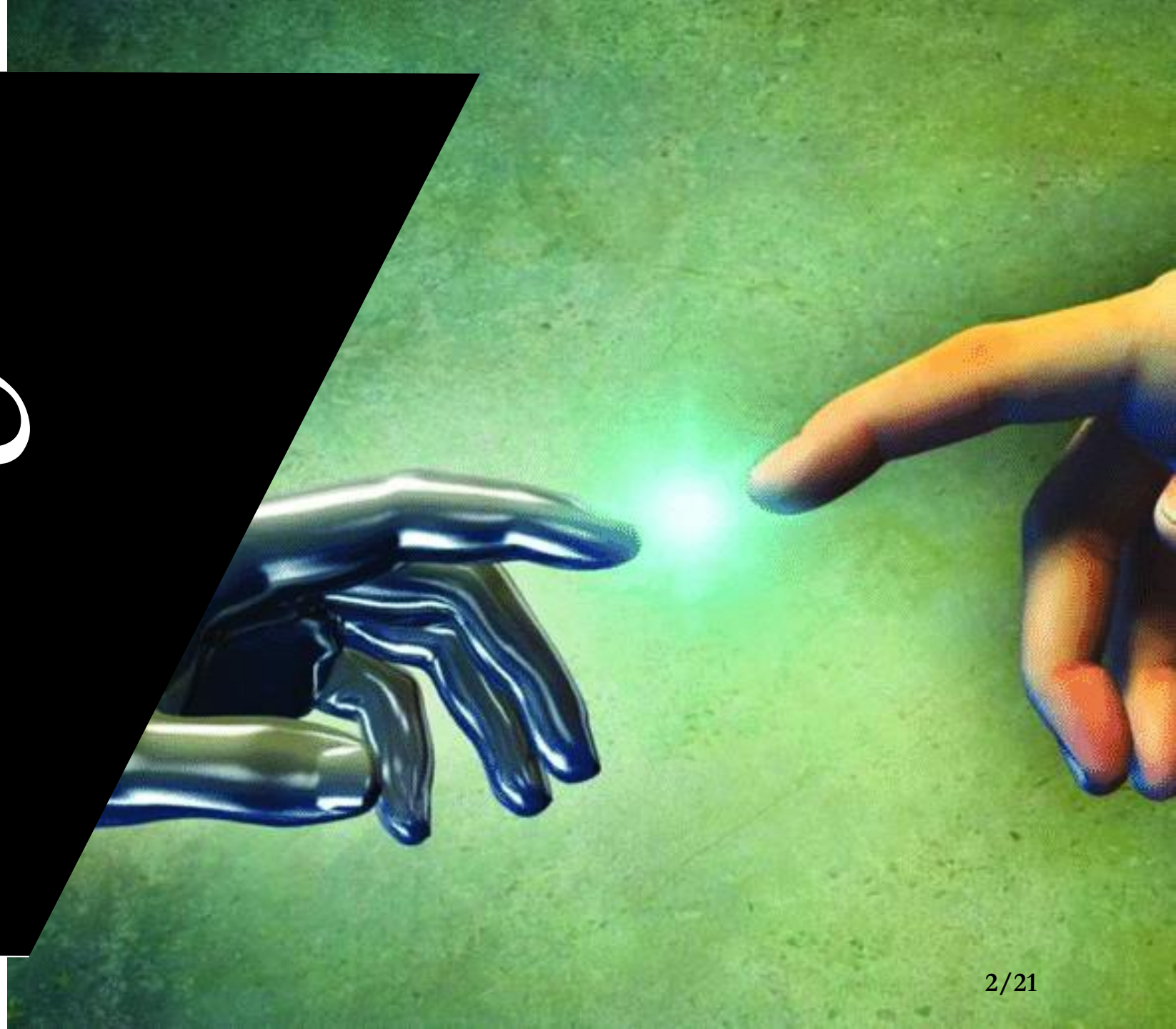
Why?



Which haptic technology is the most suitable for the virtual reality and the metaverse?

What haptic technologies can do nowadays?

Augmented Reality, Virtual Reality and Metaverse

AR: Overlay digital material in a real-world environment

VR: Three-dimensional artificial immersive environment

Metaverse: A multiuser environment which use AR and VR

Ref: [1], [2]

State of art: different haptic technologies

- Origin
- Global definition

Ref: [3]

Overview

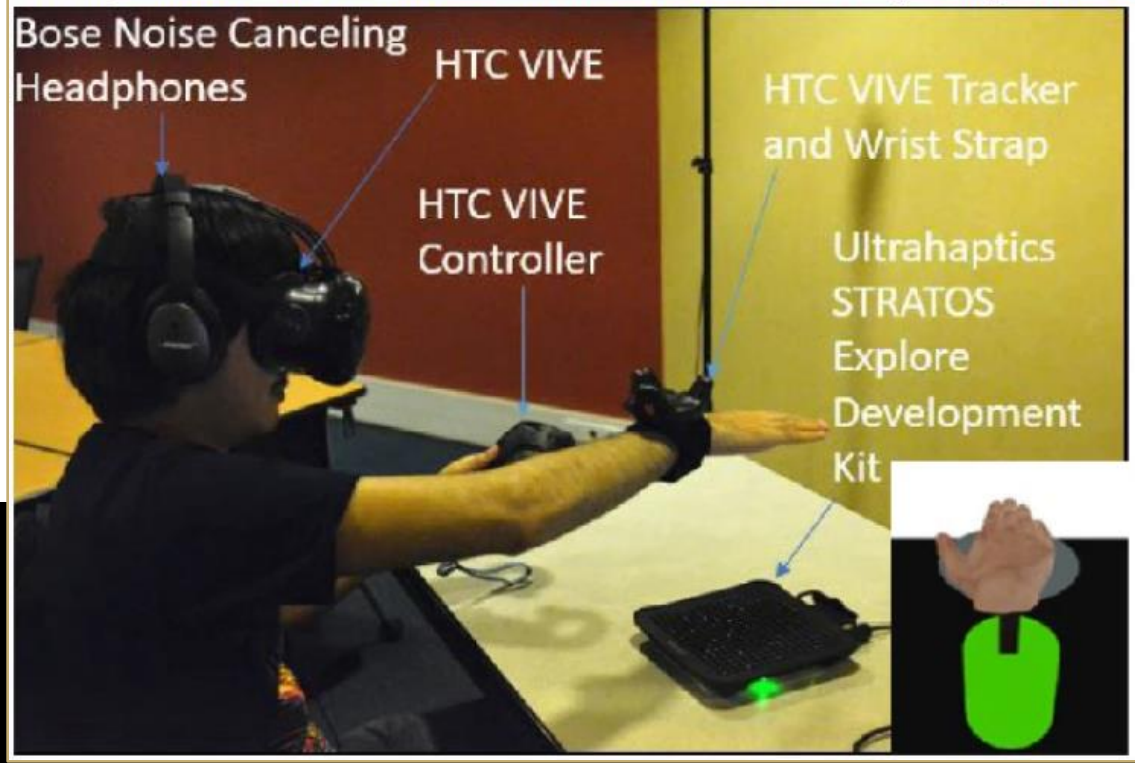
- Vibration
- Focused ultrasound
- Bioelectrical stimulation

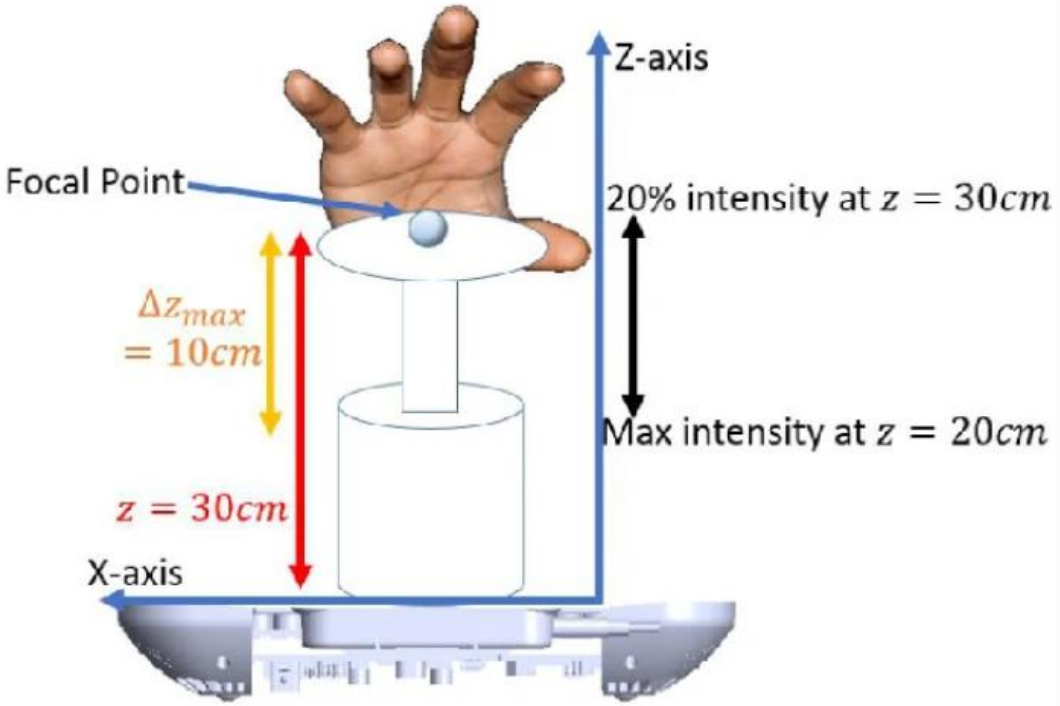
Vibration

- Eccentric Rotating Mass
- Linear Resonant Actuator
- Piezoelectric Actuator
- Surface Actuator
- Electroactive Polymers
- Capacitive electro-sensory interface

Ref: [4]

From: Can Stiffness Sensations Be Rendered in Virtual Reality Using Mid-air Ultrasound Haptic Technologies?



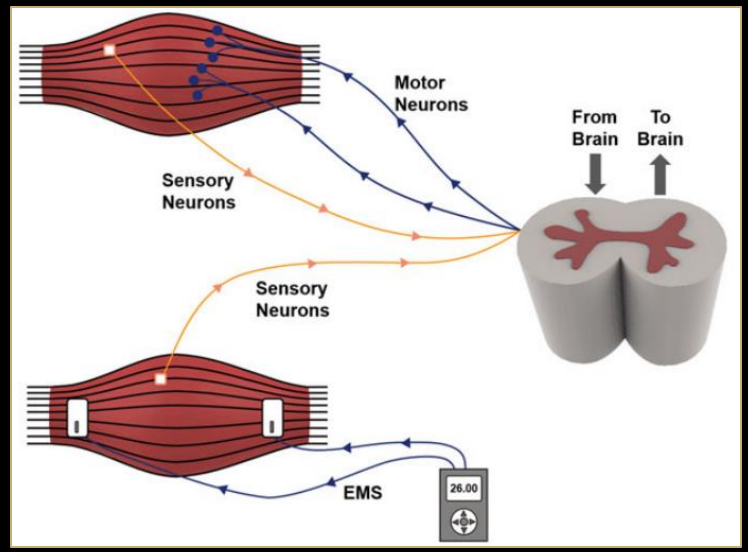


Focused ultrasound

Ref: [4]

Bioelectrical stimulation

- Functional Electrical Stimulation
- Electro stimulation
- Simulate heat and cold sensation



Ref: [4]

Existing technology: Tesla Suit

- Haptic suit
- 114 electrical sensors
- 9 axes of motion capture

Ref: [5]

Ethics in the Metaverse

- Data issues
- Breach of privacy
- Securing users' personal data
- Phycological harm

Ref: [6]

Hypothesis

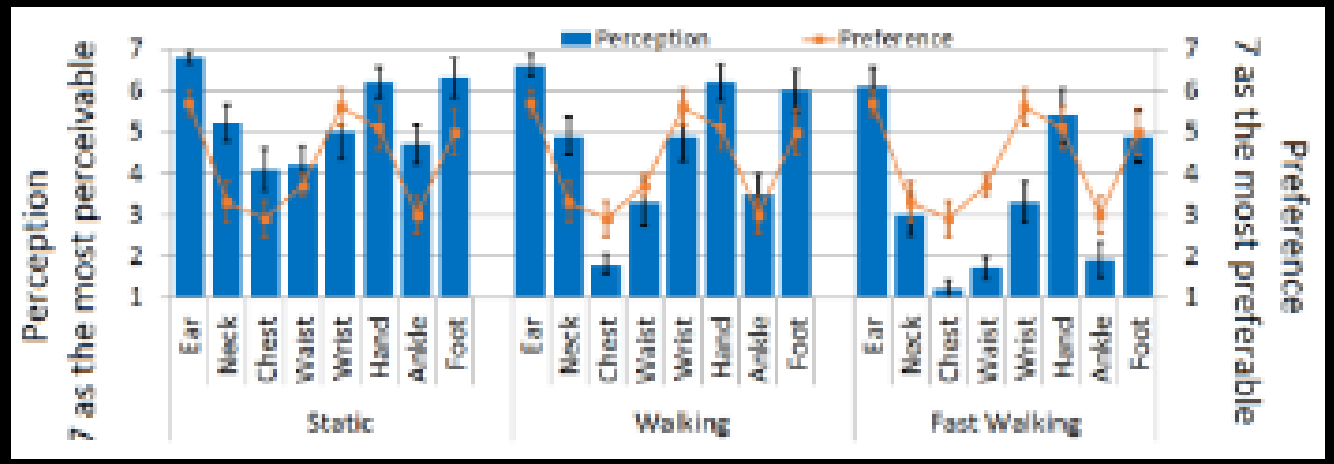
It is possible to disrupt a user's inner ear by producing different sounds that allow the user to experience haptic sensations

To enable the development of a networked haptic solution, the data transmission of the haptic technology must consume as little bandwidth as possible

And other…

Electrical nerves stimulation

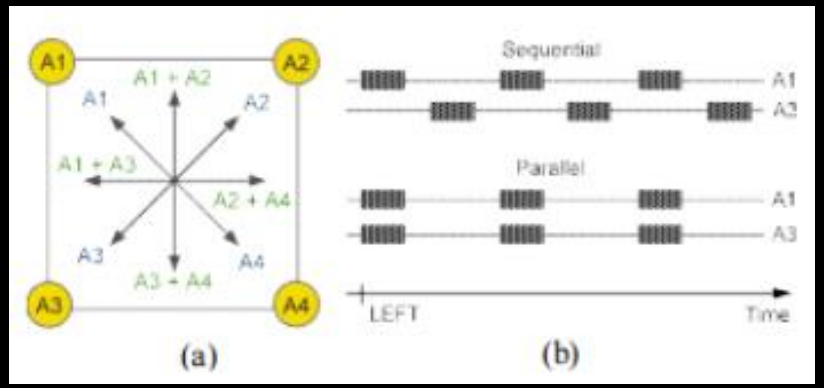
- 10 young subjects (7 males & 3 females)
- 1200 rpm (rotation per minute)
- 200 Hz of frequency
- 2.5 seconds between each vibration
- Sensation : 1 to 7 on the Likert scale

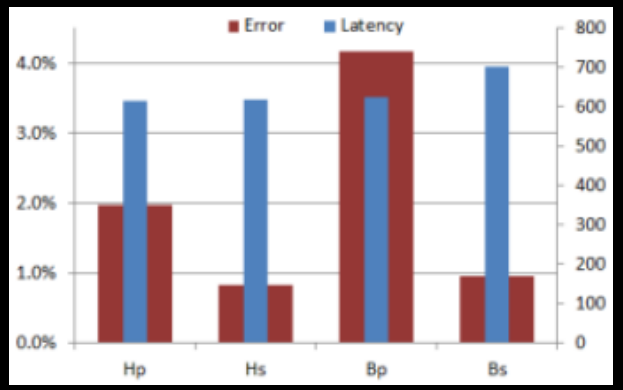


Ref: [7]

Electrical nerves stimulation

- 20 young subjects
- 2 sensors on the sides of their forehead
- 2 sensors on the neck
- 2 sensors on the back
- Sequential and parallel stimulation
- Different impulsion for different directions





Ref: [7]

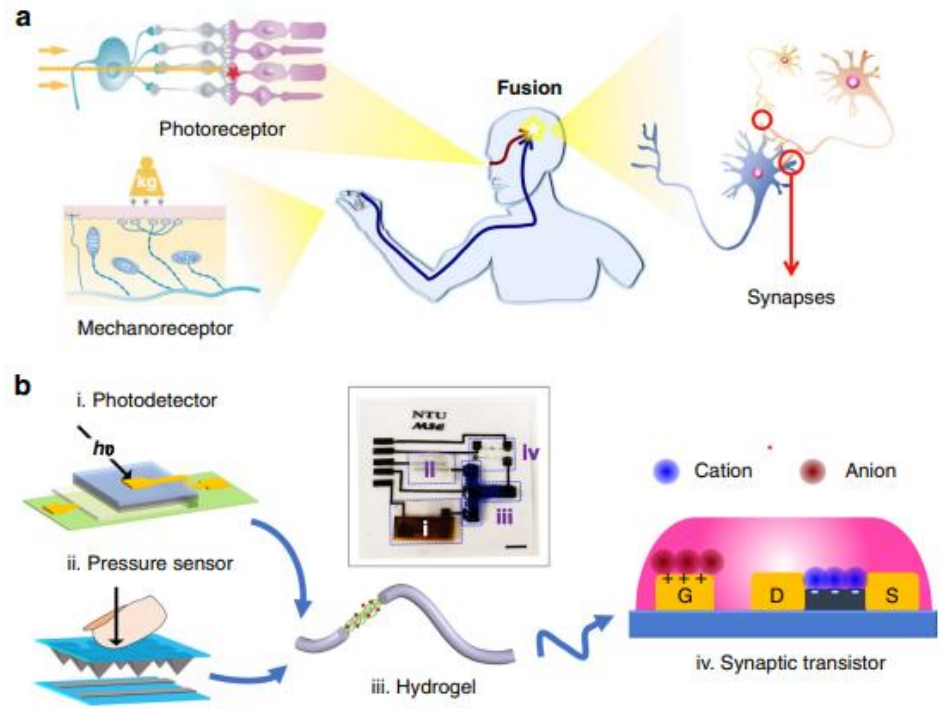
Shockwaves for Haptic Sensations

- iCone: 7m diameter, 270° FOV, conical shape, 16 speakers
- Reproduce touch thanks to vibration through the body
- Use subwoofers to generate vibrations

- Inefficient because users don't realize the haptic effect
- Jolt users body
- Haptic effects due to the user's bone structure
- Can cause health problem for some effects (blast for example)
- Enhance tactility of the sound
- Can be used to reproduce motion, collision in completion of a sound system
- Many constraints with deployment

Ref: [8]

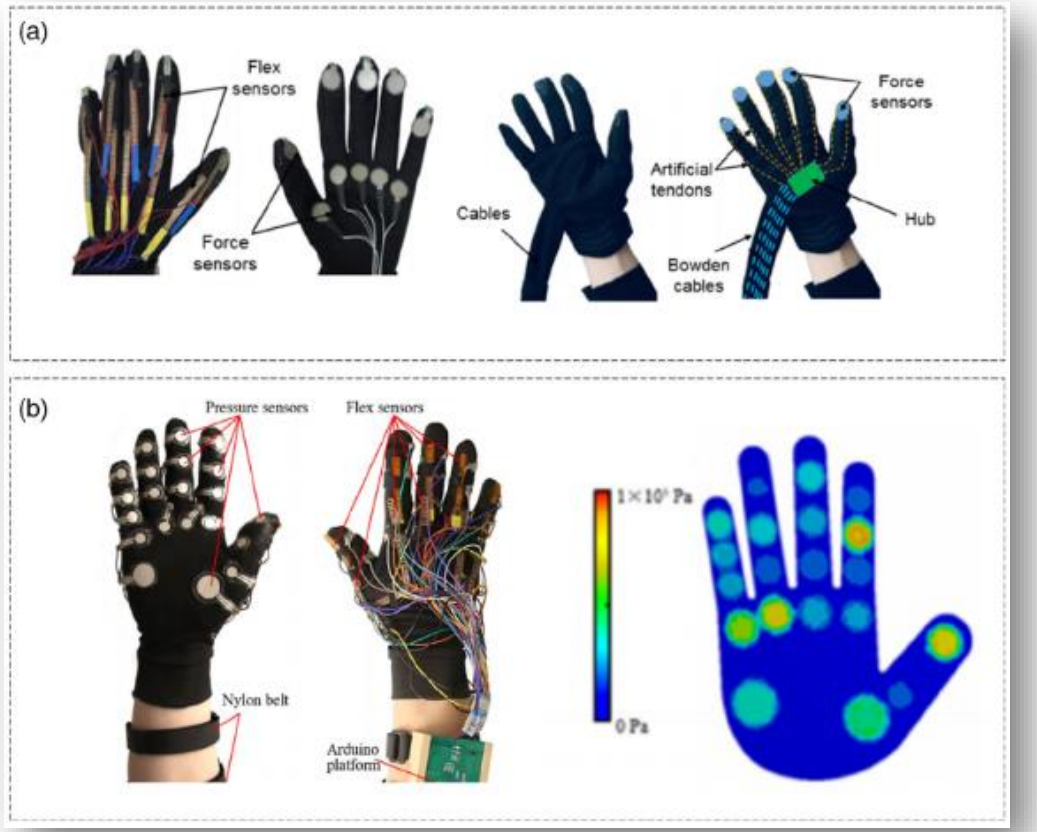
Haptic sensation by stimulating neural activity



- Biological systems always outshine their electronic counterparts
- Superior fault tolerance and power efficiency
- Hybrid neurons
- Visual channel
- Haptic channel

Ref: [9]

Haptic Gloves

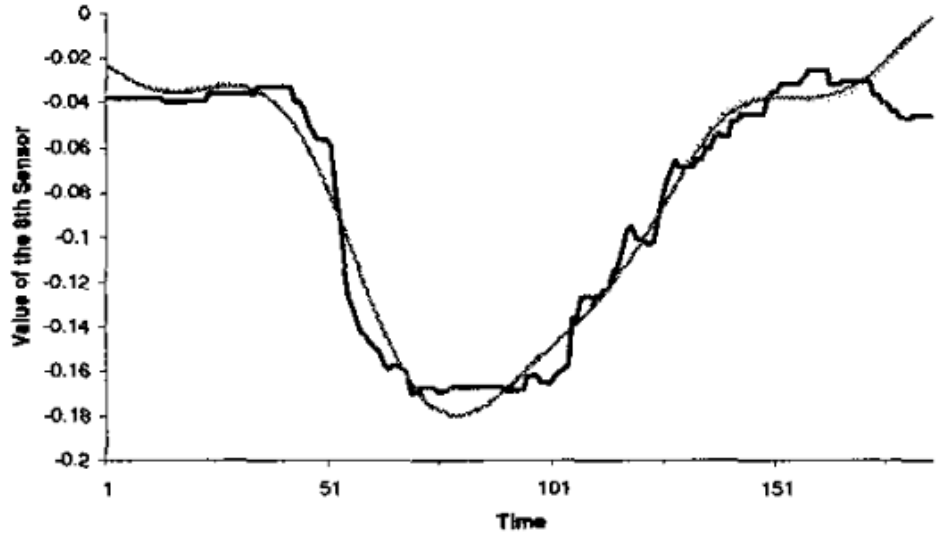


Ref: [10]

Data transmission

Position	1	2
Without compression	122	123
With Floating-point compression		+1

Ref: [11]



Comparison of the original signal to the recomposed signal after compression

Hypothesis answer

It is possible to disrupt a user's inner ear by producing different sounds that allow the user to experience haptic sensations.

=> The inner ear does not act on the sensation of touch but of movement.

To enable the development of a networked haptic solution, the data transmission of the haptic technology must consume as little bandwidth as possible.

=> The solution will use compression systems and multiplexing systems to use less bandwidth

Ref: [8], [11]

Result comparison

Haptic technologies	Benefits	Drawbacks
Sound stimulation	- Makes touch sound effects - Adapt to collision simulation	- Disturbs the inner ear - Negative health effects - Very bulky device
Electric stimulation	- True-to-life sensations - Easy to put in place - Easy to use for the user	- Poorly calibrated it can be painful
Mechanic stimulation	- Faithful sensations of inertia and force of movement - Easy to set up	- Challenging movement in the real world - Fragility of the physical device
Temperature stimulation	- Reinforces feelings of reality - Simulate hot or cold surfaces	- Poorly calibrated it can make extreme sensations - Inaccurate for texture sensations
Neural network stimulation	- Ability to simulate sight and/or hearing - Copies the functioning of a human neuron	- Difficult to set up - Little used to date - Still in the pre-test phase

Conclusion

Thanks for listening

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Annexes

Poster:

Haptic technologies for the Metaverse

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Keywords: Metaverse, haptic, ethic, virtual reality, end user

Abstract

The emergence of new technologies and services, nowadays, has broadly led to unique opportunities and ways to personalize user's experience. Regarding IT fields, more data is generated thorough the years, and we are getting closer and closer to create a realistic simulation of human sensations and feelings. However, it is definitely not easy for the client to trust or even to be aware that those technologies exist and can be used at home. Thanks to many researches and scientific experiences, we will try to provide a detailed explanation on how it is, nowadays, possible to simulate senses, and especially the touch through a virtual world. The reader will, as well, be provided feedbacks, particularly about ergonomic and therefore introducing a potential help for the user's decision-making.

Introduction

The era of virtual reality has begun. The human senses are beginning to be immersed in another world. Nowadays, the senses able to be simulated are sight and hearing. In addition, other simulations of senses are being developed, such as touch. However, many haptic technologies exist and a choice among them is necessary to perceive which technology will provide the best experience to the user. Knowing this, it is useful to consider the following problematic: which haptic technology is the most suitable for the virtual reality and the metaverse? But first, it is necessary to understand what the haptic technologies can do nowadays? Also, what is the most convenient solution for the end user? And so, do these technologies have drawbacks for the end user? In the first part of this document, we will provide an introduction to the type of tools we can work with today to build a haptic experience. Afterwards, a part will be dedicated to real scientific experiences, hence doing demonstrations and answering some questions the reader may have. Last but not least, a conclusion will be given about our final answers regarding the experiments results and our researches.

State of the art

Haptic technologies based on vibrations are the most used in the industry today. The sense of touch can be simulated by vibrations, electricity, sound, or heat [1] :

- Eccentric Rotating Mass (ERM)
- Linear Resonant Actuator (LRA)
- Piezoelectric Actuator
- Surface Actuator
- Electroactive Polymers
- Capacitive electro-sensory interface

Focused ultrasound haptics can provide the sensation of interacting with objects of different stiffness. Indeed, focused airborne ultrasound (very high intensity and focused mechanical wave). is the most advanced technology to provide airborne haptics [1].

Finally, the bioelectrical stimulation technique can improve the performance of the interaction between the human and the machine. Indeed, the haptic feedback results in the activation of the muscles by the electrical pulses. In addition, the biological study that benefits the development of functional electrical stimulation shows the composition of the sensory receptors of human fingers [2].

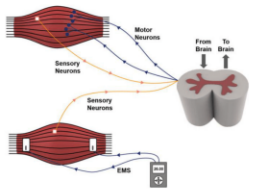

Figure 1: Electro-Myo-Stimulation (EMS) example

Validation Methodology

To validate and test our hypotheses, our team decided to read many articles related to the technologies we mentioned above. We then noted every technology's benefits and drawbacks so we could easily compare them. Finally, we made our choice regarding the end user expectations and safety

Results

Haptic technologies	Benefits	Drawbacks
Sound stimulation	- Makes touch sound effects - Adapt to collision simulation	- Disturbs the inner ear - Negative health effects - Very bulky device
Electric stimulation	- True-to-life sensations - Easy to put in place - Easy to use for the user	- Poorly calibrated it can be painful
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Figure 2: Comparison of haptic technologies

· All these different haptic technologies make it possible to experience a virtual sensation in the real world. However, some of these technologies have bigger drawbacks than others (Figure 2.). Sound stimulation can be dangerous for health, mechanical stimulation is too fragile to be manipulated according to the main problem, neural stimulation is still too experimental to be marketed, and finally, temperature stimulation does not faithfully transcribe textures and is not suitable, once again, to the main problem. The table above highlights the fact that these solutions are not suited for an end user buying a service and using the technology at home. That being said, our comparison does not mean that these are not used at all in scientific fields.

· Electrical stimulation, on the other hand, makes it possible to stimulate an environment fairly faithfully and is not as fragile. It is also widely used in virtual simulation and is no longer in the pre-test phase. Finally, it has no negative effects on health thanks to the regulation of electrical impulses, which makes it a nice candidate for a client.

· Nonetheless, neuronal technologies are beginning to be developed and seem to suit quite well to an end user experience. That being said, the uses of such technologies are very low today, and more experiences need to be performed [3].

Conclusion

The sensation of touch in virtual reality can be simulated by many haptic technologies. Those can be based on vibration, heat, sound waves or even electrical impulses. Despite the progress of these technologies nowadays, none of them are yet commercialized and all of them must be improved in the following years. That being said, we can clearly see some haptic technologies and improvements being used at home in the upcoming years. Nonetheless, this can only work if the solution for the end-user is usable through networks and understands the major ethic problems of nowadays.

Experiences have shown that electrical stimulation is the best option today for a great experience regarding the end user since it has no negative consequences in comparison to other solutions such as sound, mechanical or temperature simulation. Electrical stimulation is also relatively easy to be implemented and provide accurate haptic sensations as long as the ethic aspect is taken in account. It is important to say here that the other solutions approached in this article are still valid for many fields but do not really suit for an immersive user experience, especially in systems like VR and metaverses. Our team already see the potential behind this solution and especially in some fields related to services such as fashion, social medias, or even military. In the future, neuronal solutions seem to be conclusive, and scientists are positives that new technologies and services will soon emerge in that specific field.

References

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