

Literature Review Protocol:

The best haptic technology for virtual reality and metaverse

The protocol version 0.1 has been prepared by:

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Review History

Date	Version	Description	Author(s)
02/17/2020	0.1	First draft and definition of the initial search string	Ahlem Assila
05/03/2022	1	Adding all the information needed to fill in the blanks and prepare the research	Team number 5

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1 Introduction (investigation scenario)

First, a global definition of the study and the challenges related will be established. In order to make sure the whole team correctly understands the topic, documents will be researched, and then, a question will be asked as the main problem. This question will guide us throughout the whole process. The study will be divided into one or more constraints and several hypotheses about the topic. The major parts of the article will be brainstormed and will allow us to write the state of the art thanks to the document we will find. Finally, after testing the hypotheses, solutions will be proposed, and a conclusion will be drawn.

2 Research Protocol

2.1 Question Focus

The objective of this literature review is to find the criteria that will help us to choose our references for the study. That way, it will be easier for us to deeply understand the topic and then compare the different technologies that exist nowadays in the scientific article we will write soon.

2.2 Question Quality and Amplitude

- **Problem:** The idea of a clothes shop in the metaverse with the possibility of touching and feeling the clothes as if we were wearing them implies a certain rigor when looking for the right technology. Nowadays, many different technologies exist, and it is not always easy to choose. We are, therefore, looking for the haptic technology that suits our idea and the end user the most.
- **Question:**
 - **Main Question:**
 - Which haptic technology is the most suitable for the virtual reality and the metaverse?
 - **Secondary questions:**
 - What is the haptic technology able to do?
 - What is the most convenient (cost, ergonomic, ...) solution for the end user?
 - Do these technologies have drawbacks for the end user?
- **Keywords:** Metaverse, haptic, ethic, virtual reality, end user

2.3 Source Selection

2.3.1 Sources Selection Criteria Definition:

Peer-reviewed works (journal articles, conference papers or workshop papers) should be available on the web.

2.3.2 Studies Language: English.

2.3.3 Source Identification

- **Source Search Method:** Search through web search engines.
- **Search Engines:**

Table 1: Search engines

Name	Link
Google Scholar	https://scholar.google.com/
Science	https://www.science.org/
Research Gate	https://www.researchgate.net/
Science Direct	https://www.sciencedirect.com/
IEEE Xplore	https://ieeexplore.ieee.org/Xplore/home.jsp
Online Library	https://onlinelibrary.wiley.com/
Springer	https://link.springer.com/

- **Search String:**
 - allintitle: “Haptic technology virtual reality” OR “Haptic technology metaverse”
 - allintitle: “Experiments haptic technology virtual reality” OR “Experiments haptic technology metaverse”
 - allintitle: “Touch in virtual reality” OR “Touch in metaverse”

2.4 Studies Selection

2.4.1 Studies Definition

- **Studies Inclusion and Exclusion Criteria Definition:**
 - **Inclusion Criteria:**
 - To talk about a haptic technology in virtual reality/metaverse
 - To talk about an experiment of one haptic technology
 - **Exclusion Criteria:**
 - Not talking about a haptic technology.
 - Books, book chapters that are not from conference proceedings, book prefaces, summaries of conferences, editorials, tutorials, retracted articles.
 - Articles presenting partial results of a complete study that is selected.
 - Not being available.

- Studies in duplicity.
 - Not in English.
- **Procedures for studies selection:** Read the title and the abstract of the studies found and evaluating according to inclusion and exclusion criteria.
 - **Acceptance Criteria:** Four distinct readers evaluated each study. The discussion scenery involves the readers expressing the rationale behind the choice and reaches a consensus to include or exclude the study under discussion. The studies acceptance criteria happened as follows:

Table 2: Acceptance criteria among the readers

Reader 1	Reader 2	Reader 3	Reader 4	Final
Include	Include	Include	Doubt	Include
Include	Include	Doubt	Doubt	Include
Include	Include	Doubt	Exclude	Include
Include	Include	Include	Include	Include
Exclude	Include	Include	Include	Include
Doubt	Doubt	Exclude	Exclude	Exclude
Doubt	Exclude	Exclude	Exclude	Exclude
Exclude	Exclude	Exclude	Exclude	Exclude
Exclude	Exclude	Exclude	Include	Exclude
Exclude	Exclude	Doubt	Include	Exclude
Include	Doubt	Doubt	Doubt	Discussion
Doubt	Doubt	Doubt	Doubt	Discussion
Doubt	Doubt	Doubt	Exclude	Discussion
Doubt	Doubt	Include	Exclude	Discussion
Exclude	Exclude	Include	Include	Discussion

2.5 Execution Results

Extraction from the database was carried out on 05/03/2022. Table 3 shows the references retrieved by each search engine, and Table 4 shows each stage of the review.

Table 3: Search Engines Result

Search Engine	Number of articles found
Google Scholar	3
Science	3
Research Gate	2
Science Direct	1
IEEE Xplore	8
Online Library	1
Link Springer	4
TOTAL	22

Table 4: Total of articles at each stage of the review

Stage	Number of articles
Articles found Google Scholar	22
Duplicates (all data base)	0
Articles selected to read (title and abstract)	22
Articles selected by the inclusion criteria	12
Articles selected after meeting of the reviewers	3
Articles kept after full reading	15

2.6 Information extraction strategy

For each selected paper the following information shall be extracted and managed using the JabRef reference tool (<http://www.jabref.org/>):

Article 1:

Field	Description
Title	Reach out and touch me: effects of four distinct haptic technologies on affective touch in virtual reality
Authors	Imtiaj Ahmed, Ville Harjunen, Giulio Jacucci, Eve Hoggan, Niklas Ravaja, Michiel M. Spapé
Year of Publication	2016
Source of Publication	ACM Digital Library
Abstract	Virtual reality presents an extraordinary platform for multimodal communication. Haptic technologies have been shown to provide an important contribution to this by facilitating co-presence and allowing affective communication. However, the findings of the affective influences rely on studies that have used myriad different types of haptic technology, making it likely that some forms of tactile feedback are more efficient in communicating emotions than others. To find out whether this is true and which haptic technologies are most effective, we measured user experience during a communication scenario featuring an affective agent and interpersonal touch in virtual reality. Interpersonal touch was simulated using two types of vibrotactile actuators and two types of force feedback mechanisms. Self-reports of subjective experience of the agent's touch and emotions were obtained. The results revealed that, regardless of the agent's expression, force feedback actuators were rated as more natural and resulted in greater emotional interdependence and a stronger sense of co-presence than vibrotactile touch.
URL	https://dl.acm.org/doi/abs/10.1145/2993148.2993171

Question	How can a touch in virtual reality create emotions?
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Article 2:

Field	Description
Title	Recent Advances and Opportunities of Active Materials for Haptic Technologies in Virtual and Augmented Reality
Authors	Tae-Heon Yang, Jin Ryong Kim, Hanbit Jin, Hyunjae Gil, Jeong-Hoi Koo, Hye Jin Kim (nolawara@etri.re.kr)
Year of Publication	2021
Source of Publication	Online Library
Abstract	Virtual reality and augmented reality (VR/AR) are evolving. The market demands and innovation efforts call for a shift in the key VR/AR technologies and engaging people virtually. Tele-haptics with multimodal and bilateral interactions are emerging as the future of the VR/AR industry. By transmitting and receiving haptic sensations wirelessly, tele-haptics allow human-to-human interactions beyond the traditional VR/AR interactions. The core technologies for tele-haptics include multimodal tactile sensing and feedback based on highly advanced sensors and actuators. Recent developments of haptic innovations based on active materials show that active materials can significantly contribute to addressing the needs and challenges for the current and future VR/AR technologies. Thus, this paper intends to review the current status and opportunities of active material-based haptic technology with a focus on VR/AR applications. It first provides an overview of the current VR/AR applications of active materials for haptic sensing and actuation. It then highlights the state-of-the-art haptic interfaces that are relevant to the materials with an aim to provide perspectives on the role of active materials and their potential integration in haptic devices. This paper concludes with the perspective and outlook of immersive multimodal tele-haptic interaction technologies.
URL	https://onlinelibrary.wiley.com/doi/full/10.1002/adfm.202008831
Question	How can wireless technologies support haptic technologies?

Article 3:

Field	Description
Title	Can Stiffness Sensations Be Rendered in Virtual Reality Using Mid-air Ultrasound Haptic Technologies?
Authors	M. Marchal, G. Gallagher, A. Lécuyer, C. Pacchierotti

Year of Publication	2020
Source of Publication	Springer
Abstract	Mid-air haptics technologies convey haptic sensations without any direct contact between the user and the interface. A popular example of this technology is focused ultrasound. It works by modulating the phase of an array of ultrasound emitters so as to generate focused points of oscillating high pressure, which in turn elicit haptic sensations on the user's skin. Whilst using focused ultrasound to convey haptic sensations is becoming increasingly popular in Virtual Reality (VR), few studies have been conducted into understanding how to render virtual object properties. In this paper, we evaluate the capability of focused ultrasound arrays to simulate varying stiffness sensations in VR. We carry out a user study enrolling 20 participants, showing that focused ultrasound haptics can well provide the sensation of interacting with objects of different stiffnesses. Finally, we propose four representative VR use cases to show the potential of rendering stiffness sensations using this mid-air haptics.
URL	https://link.springer.com/content/pdf/10.1007/978-3-030-58147-3.pdf

Article 4:

Field	Description
Title	Stiffness modulation for Haptic Augmented Reality: Extension to 3D interaction
Authors	Seokhee Jeon; Seungmoon Choi
Year of Publication	2010
Source of Publication	IEEE Explore
Abstract	Haptic Augmented Reality (AR) allows a user to touch a real environment augmented with synthetic haptic stimuli. For example, medical students can palpate a virtual tumor inside a real mannequin using a haptic AR system to practice cancer detection. To realize such functionality, we need to alter the haptic attributes of a real object by means of virtual haptic feedback. Previously, we presented a haptic AR system with stiffness as a goal modulation property, and demonstrated its competent physical and perceptual performances for 1D interaction. In this paper, we extend the system so that a user can interact with a real object in any 3D exploratory pattern while perceiving its augmented stiffness. A series of algorithms are developed for contact detection, deformation estimation, force rendering, and force control. Their performances are thoroughly evaluated with real samples. A particular focus has been on minimizing the amount of preprocessing such as geometry modeling. Our haptic AR system can provide convincing stiffness modulation for real objects of relatively homogeneous deformation properties. The

	limitations of our AR system are also discussed along with a plan for future work.
URL	https://ieeexplore.ieee.org/document/5444645%20
Question	How is it possible to simulate an illness such as a tumor?

Article 5:

Field	Description
Title	The Potential of Haptics Technologies
Authors	Abdulmotaleb El Saddik
Year of Publication	2007
Source of Publication	IEEE Explore
Abstract	In spite of the significant recent progress, the incorporation of haptics into virtual environments is still in its infancy due to limitations in the hardware, the cost of development, as well as the level of reality they provide. Nonetheless, we believe that the field will one day be one of the groundbreaking media of the future. It has its current holdups but the promise of the future is worth the wait. The technology is becoming cheaper and applications are becoming more forthcoming and apparent. If we can survive this infancy, it will promise to be an amazing revolution in the way we interact with computers and the virtual world. The researchers organize the rapidly increasing multidisciplinary research of haptics into four subareas: human haptics, machine haptics, computer haptics, and multimedia haptics.
URL	https://ieeexplore.ieee.org/abstract/document/4140943

Article 6:

Field	Description
Title	Haptic Technology: A comprehensive review on its applications and future prospects
Authors	M.Sreelakshmi, T.D.Subash
Year of Publication	2007
Source of Publication	ScienceDirect
Abstract	Computer Science finds a variety of applications in different fields. In the modern scenario, the combination of human senses with field of computer science is becoming more and more common. A detailed study of haptic technology is described in this paper which is entirely related to touch. The complete potential of the field is yet to be explored. The science of applying touch sensation and control to interact with computer developed applications is the best definition given for haptic technology. With the help of Haptic device people get a sense of touch with computer generated environments, so that when virtual objects are touched, they seem to be real and tangible. Haptic technology enables

	the user to interface with a virtual environment via the sense of touch by applying forces, vibrations, or motions to the user. This mechanical simulation helps in the creation of virtual objects, controlling of virtual objects and to augment the remote control properties of machines and devices. This paper describes how haptic technology works, its devices, applications, and disadvantages. A brief explanation on haptics functions and its implementation in various fields of study is provided in this paper. A description on some of its future applications and a few limitations of this technology is also provided.
URL	https://www.sciencedirect.com/science/article/pii/S2214785317303188

Article 7:

Field	Description
Title	Haptic Handshank – A Handheld Multimodal Haptic Feedback Controller for Virtual Reality
Authors	K M Arafat Aziz, Hu Luo, Lehiany Asma, Weiliang Xu, Yuru Zhang, Dangxiao Wang
Year of Publication	2020
Source of Publication	IEEE Explore
Abstract	Compared to wearable devices, handheld haptic devices are promising for large scale virtual reality applications because of their portability and capability of supporting large workspace haptic interaction. However, it remains a challenge to render multimodal haptic stimuli in handheld devices due to space confinement. In this paper, we present a modular approach to build a Multimodal Handheld Haptic Controller called “Haptic Handshank” that includes a thumb feedback component, a palm feedback component, and a motion tracking component. In the thumb feedback component, a compact pneumatically driven silicone airbag is utilized to simulate softness, and a flexible membrane based on the electro-vibration principle which covers the top portion of the airbag for rendering virtual textures. In the palm feedback component, vibrational motors and Peltier devices are embedded into the device's body for rendering vibrotactile flow and distributing thermal stimuli. In the motion tracking component, an HTC-Vive tracker is mounted on the bottom of the controller's handle to enable 6-DOF palm motion tracking. The performance of the handheld device is evaluated through quantitative experimental studies, which validate the ability of the device to simulate multimodal haptic sensations in accordance with diverse hand manipulation gestures such as enclosure, static contact, rubbing, squeezing and shaking of a cup of cold drink in 3D virtual space.
URL	https://ieeexplore.ieee.org/document/9284696
Question	How to miniaturize such technologies as haptic components?

Article 8:

Field	Description
Title	Concept and application of virtual reality haptic technology: a review
Authors	Nuratiqa Natrah Mansor, Muhammad Herman Jamaluddin, Ahmad Zaki Shukor (zealousanne@gmail.com, herman@utem.edu.my, zaki@utem.edu.my)
Year of Publication	2017
Source of Publication	Research Gate
Abstract	Haptics has been a major part of both future virtual reality experiences and everyday consumer electronics. Wearable technology, since it is in contact with human skins, will be the most likely place to deploy these solutions. Haptics platform is a fast-evolving area and the virtual reality technologies has matured and is giving suitable assistance to robotic surgery and people who are handicapped. This paper reviews the general concept of virtual reality haptics, altogether with its applications, previous research findings, the challenge, and its superiority for developing a virtual reality prototype/devices and integration of virtual reality concept with the bilateral control system platform. And lastly, potential upcoming works were discussed, and suggestions will be put together for melioration of review findings.
URL	https://www.researchgate.net/publication/319096104_Concept_and_application_of_virtual_reality_haptic_technology_A_review

Article 9:

Field	Description
Title	Interactive representation of virtual object in hand-held box by finger-worn haptic display
Authors	Kouta Minamizawa; Souichiro Fukamachi; Naoki Kawakami; Susumu Tachi
Year of Publication	2008
Source of Publication	IEEE Explorer
Abstract	To deliver a realistic presence of virtual objects with a simple haptic display in an augmented reality system, we have developed a wearable haptic display to present the sensation of weight and inertial force of the virtual objects. In this study, we developed an augmented reality application for our haptic device that represents the dynamics of the virtual objects inside a real box based on a physical simulation. We implemented the prototype system to represent a virtual ball in a real box and evaluated the capability of our proposed method.
URL	https://ieeexplore.ieee.org/document/4479973

Question	Are haptic technologies really able to precisely reproduce the physics of our world?
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Article 10:

Field	Description
Title	Combining Dynamic Passive Haptics and Haptic Retargeting for Enhanced Haptic Feedback in Virtual Reality
Authors	André Zenner, Kristin Ullmann, Antonio Krüger
Year of Publication	2021
Source of Publication	IEEE
Abstract	<p>To provide immersive haptic experiences, proxy-based haptic feedback systems for virtual reality (VR) face two central challenges: (1) similarity, and (2) colocation. While to solve challenge (1), physical proxy objects need to be sufficiently similar to their virtual counterparts in terms of haptic properties, for challenge (2), proxies and virtual counterparts need to be sufficiently colocated to allow for seamless interactions. To solve these challenges, past research introduced, among others, two successful techniques: (a) Dynamic Passive Haptic Feedback (DPHF), a hardware-based technique that leverages actuated props adapting their physical state during the VR experience, and (b) Haptic Retargeting, a software-based technique leveraging hand redirection to bridge spatial offsets between real and virtual objects. Both concepts have, up to now, not ever been studied in combination. This paper proposes to combine both techniques and reports on the results of a perceptual and a psychophysical experiment situated in a proof-of-concept scenario focused on the perception of virtual weight distribution. We show that users in VR overestimate weight shifts and that, when DPHF and HR are combined, significantly greater shifts can be rendered, compared to using only a weight-shifting prop or unnoticeable hand redirection. Moreover, we find the combination of DPHF and HR to let significantly larger spatial dislocations of proxy and virtual counterpart go unnoticed by users. Our investigation is the first to show the value of combining DPHF and HR in practice, validating that their combination can better solve the challenges of similarity and colocation than the individual techniques can do alone.</p>
URL	https://ieeexplore.ieee.org/document/9382898

Article 11:

Field	Description
Title	Surface haptic rendering of virtual shapes through change in surface temperature
Authors	Changhyun Choi, Yuan Ma, Xinyi Li, Sitangshu Chatterjee, sneha Sequeira, Rebecca F. Friesen, Jonathan R. Felts and M. Cynthia Hipwell
Year of Publication	2022
Source of Publication	Science
Abstract	Compared to relatively mature audio and video human-machine interfaces, providing accurate and immersive touch sensation remains a challenge owing to the substantial mechanical and neurophysical complexity of touch. Touch sensations during relative lateral motion between a skin-screen interface are largely dictated by interfacial friction, so controlling interfacial friction has the potential for realistic mimicry of surface texture, shape, and material composition. In this work, we show a large modulation of finger friction by locally changing surface temperature. Experiments showed that finger friction can be increased by ~50% with a surface temperature increase from 23° to 42°C, which was attributed to the temperature dependence of the viscoelasticity and the moisture level of human skin. Rendering virtual features, including zoning and bump(s), without thermal perception was further demonstrated with surface temperature modulation. This method of modulating finger friction has potential applications in gaming, virtual and augmented reality, and touchscreen human-machine interaction.
URL	https://www.science.org/doi/10.1126/scirobotics.abl4543

Article 12:

Field	Description
Title	Haptic-feedback smart glove as a creative human-machine interface (HMI) for virtual/augmented reality applications
Authors	Minglu Zhu, Zixuan Zhang, Qiongfeng Shi, Tianyi He, Huicong Liu, Tao Chen, Chengkuo Lee
Year of Publication	2020
Source of Publication	Science Advances
Abstract	Human-machine interfaces (HMIs) experience increasing requirements for intuitive and effective manipulation. Current commercialized solutions of glove-based HMI are limited by

	<p>either detectable motions or the huge cost on fabrication, energy, and computing power. We propose the haptic-feedback smart glove with triboelectric-based finger bending sensors, palm sliding sensor, and piezoelectric mechanical stimulators. The detection of multidirectional bending and sliding events is demonstrated in virtual space using the self-generated triboelectric signals for various degrees of freedom on human hand. We also perform haptic mechanical stimulation via piezoelectric chips to realize the augmented HMI. The smart glove achieves object recognition using machine learning technique, with an accuracy of 96%. Through the integrated demonstration of multidimensional manipulation, haptic feedback, and AI-based object recognition, our glove reveals its potential as a promising solution for low-cost and advanced human-machine interaction, which can benefit diversified areas, including entertainment, home healthcare, sports training, and medical industry.</p>
URL	https://www.science.org/doi/10.1126/sciadv.aaz8693

Article 13:

Field	Description
Title	A New Interactive Haptic Device for Getting Physical Contact Feeling of Virtual Objects
Authors	Keishirou Kataoka; Takuya Yamamoto; Mai Otsuki; Fumihisa Shibata; Asako Kimura
Year of Publication	2019
Source of Publication	IEEE
Abstract	<p>The emergence of new and inexpensive virtual reality (VR) technology has made it relatively familiar to most users. We can create virtual 3D objects and paint on them in a VR space. Many of the VR controllers used for such operations provide haptic feedbacks by vibration when the user touches the virtual objects. In the real world, we can perceive not only the touch sensation but also the reaction force when touching and stroking the object's surface. However, it is impossible to provide a reaction force only with the vibration feedback. That is, there is a sensory gap between the VR space and the real world. The gap makes it difficult to work in the VR space in a manner similar to that in the real world. In this study, we focused on providing the reaction force from the virtual object to the user and proposed a device that could provide the force feedback to the user's arm without connecting the device to large equipment.</p>
URL	https://ieeexplore.ieee.org/document/8797762

Article 14:

Field	Description
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Title	Social Touch Technology: A Survey of Haptic Technology for Social Touch
Authors	Gijs Huisman
Year of Publication	2017
Source of Publication	IEEE
Abstract	This survey provides an overview of work on haptic technology for social touch. Social touch has been studied extensively in psychology and neuroscience. With the development of new technologies, it is now possible to engage in social touch at a distance or engage in social touch with artificial social agents. Social touch research has inspired research into technology mediated social touch, and this line of research has found effects similar to actual social touch. The importance of haptic stimulus qualities, multimodal cues, and contextual factors in technology mediated social touch is discussed. This survey is concluded by reflecting on the current state of research into social touch technology and providing suggestions for future research and applications.
URL	https://ieeexplore.ieee.org/abstract/document/7811300
Question	Why the sensation of feeling a human virtually can be interesting in the metaverse?

Article 15:

Field	Description
Title	Generic Control Interface for Networked Haptic Virtual Environments
Authors	Priscilla Ramsamy, Adrian Haffegge, Vassil Alexandrov
Year of Publication	2017
Source of Publication	SpringerLink
Abstract	As Virtual Reality pushes the boundaries of the human computer interface new ways of interaction are emerging. One such technology is the integration of haptic interfaces (force-feedback devices) into virtual environments. This modality offers an improved sense of immersion to that achieved when relying only on audio and visual modalities. The paper introduces some of the technical obstacles such as latency and network traffic that need to be overcome for maintaining a high degree of immersion during haptic tasks. The paper describes the advantages of integrating haptic feedback into systems and presents some of the technical issues inherent in a networked haptic virtual environment. A generic control interface has been developed to seamlessly mesh with existing networked VR development libraries.
URL	https://link.springer.com/chapter/10.1007/978-3-540-72586-2_109

3 Analysis

3.1 Justification of choices

Article 1: “Reach out and touch me: effects of four distinct haptic technologies on affective touch in virtual reality”

This article talks about different haptic technologies (four) and do some tests for each one of them. These “low-cost” technologies can be used to mimic interpersonal touch which might be interesting if we try to simulate the end user. About the question, the touch probably sends a signal to the brain and then creates an emotion understandable by the human mind.

Article 2: “Recent Advances and Opportunities of Active Materials for Haptic Technologies in Virtual and Augmented Reality”

This article exposes five different haptic technologies and puts forward their different methods, strengths, challenges, opportunities, and applications. It also talks about the cost of the technology and the user experience (secondary question in our case). The wireless haptic technologies probably work thanks to the emission of signals through a specific network somehow linked to a human for instance.

Article 3: “Haptics: Science, Technology, Applications”

This book exposes a lot of information. The most interesting ones are about the different haptic technologies and the feedbacks from users (some children test the technology for instance). Furthermore, it discusses the precision of the haptic technology nowadays which could be interesting for comparison later.

Article 4: “Stiffness modulation for Haptic Augmented Reality: Extension to 3D interaction”

This article will help us to understand the real capabilities of the haptic technology in a reality augmented environment. It does that since the whole document is based on the development of a system allowing humans to touch a virtual cancer in a real mannequin. Regarding the question, our team has, for now, no real idea about how such a technology can work. However, we think that it might be interesting to see solutions with high potential like this one in our solutions.

Article 5: “The Potential of Haptics Technologies”

This article will define what haptic technology is. Four subfields are addressed in this article: human haptics, machine haptics, computer haptics and multimedia haptics. These four fields will allow us to have an overview of haptic systems and their usefulness in the world today as well as in the future.

Article 6: “Haptic Technology: A comprehensive review on its applications and future prospects”

This article will help us to answer the main question. Indeed, different haptic technologies are mentioned in this document, which will make the choice between many technologies much simpler for the study.

Article 7: “Haptic Handshank – A Handheld Multimodal Haptic Feedback Controller for Virtual Reality”

The article describes how a multimodal handheld haptic controller works. It will help us to answer the main question since we will be able to add another technology to compare. Some details are given about the use of the technology, which will be helpful to precisely understand how we can make our solution easy to use in the metaverse. We understand that haptic technologies become smaller with the time and the recent innovations the same way computer components become also really small.

Article 8: “Concept and application of virtual reality haptic technology: a review”

This one is easy to understand and already compares multiple virtual reality products that are commercialized nowadays. This is pretty much our main question and also one of the secondaries (with the cost of the products for the users). Also, the document presents a state of the art about virtual reality in multiple fields, something that we will have to write in the next document.

Article 9: “Interactive representation of virtual object in hand-held box by finger-worn haptic display”

This article presents another way of using haptic technologies, but this time, on a finger. The whole object is detailed, and an experiment is given at the end of the document. It makes us understand how it is possible to feel the objects when we touch them through a haptic system, something we want the reader to understand (secondaries questions) for the innovation to work. Haptic technologies are not made in the first place to reproduce our world physic (and therefore are limited in that field) but to create a sensation of touch.

Article 10: “Combining Dynamic Passive Haptics and Haptic Retargeting for Enhanced Haptic Feedback in Virtual Reality”

This paper highlights the lack of similarity of skin suits. This suit gives users the sensation of touch in virtual and augmented reality. Our system offers users the possibility to try on clothes, so the suit allows us to feel the clothes while trying them on. This article helps us to decide which technology is better. In short, it will allow us to answer the question related to the most convenient solution for the end user.

Article 11: “Surface haptic rendering of virtual shapes through change in surface temperature”

The main topic of this article is the sensation of touch using the fiction method. This article focuses on the detection of temperature variation of surface materials. This article will be useful in answering the question about skin technology and more specifically about the sensation of touch.

Article 12: “Haptic-feedback smart glove as a creative human-machine interface (HMI) for virtual/augmented reality applications”

Our system is clearly a human-machine interaction and is based on the sensation of touch. This article highlights, not only the degree of flexibility of hand movements, but also the ability to recognize object types, which in our case is the material of clothing. Thanks to the glove which is not very bulky and the lower acquisition cost, it goes without saying that this article will allow us to answer the question related to the cost and ergonomics for the end user.

Article 13: “A New Interactive Haptic Device for Getting Physical Contact Feeling of Virtual Objects”

The paper shows the difference between real-world feelings and virtual reality feelings when we stroke an object. It demonstrates how we can produce force feedback and feelings on a user’s arm without large equipment. It brings a new manner to experience physically virtual objects. We will be able to compare this technology to the others and to evaluate the feasibility of this technology.

Article 14: “Social Touch Technology: A Survey of Haptic Technology for Social Touch”

This paper provides an overview of haptic technology applicable to social touch. It brings some notions of psychology and neuroscience to analyze the quality of haptic technologies. We will be then able to answer the question about the convenience and the drawbacks of these technologies for the end user. The sensation of feeling a human through metaverse is interesting and might open the way to new technologies. However, it is important to remember that some people also just want to be alone and feel safe in their own environment (might cause some ethic issues).

Article 15: “Generic Control Interface for Networked Haptic Virtual Environments”

This paper reports the technical obstacle that will represent Internet for our haptic technology. Transporting a large amount of data with a minimum latency will not be doable if the number of haptic devices on the network becomes too big. It will impact the end user’s experience. This paper proposes a generic control interface to palliate the problem. We will then be able to report if the technologies are realistic to do.

3.2 Selected Studies

- <https://dl.acm.org/doi/abs/10.1145/2993148.2993171>
- <https://onlinelibrary.wiley.com/doi/full/10.1002/adfm.202008831>
- https://link.springer.com/chapter/10.1007/978-3-030-58147-3_33
- <https://ieeexplore.ieee.org/document/5444645>
- <https://ieeexplore.ieee.org/abstract/document/4140943>
- https://www.researchgate.net/publication/319096104_Concept_and_application_of_virtual_reality_haptic_technology_A_review
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