Lite review

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***Abstract*—abstract**
***Index Terms*—VR, MR, Devices**

I. Introduction

First draft: only Bullet points JONI SUCKS PEEPEE
TODO: Topic & relevance
TODO: the problem this paper addresses
This paper aims to adapt the methodology from Veys et al. [**?**] to a study focused on generating ideas for a privacy centric application to exercise GDPR rights in regards to data downloads and collection from online services instead of an application that only visualizes said data.
TODO: outline of the remaining paper

II. Related Work

In recent years, the landscapes of Virtual Reality (VR) and Augmented Reality (AR) have undergone significant transformations. Central to this evolution is haptic technology, which has redefined user immersion by facilitating tangible interactions within virtual environments. While we aim to focus on the advancements over the past five years, a foundational base for our study was the work of Adilkhanov et al [1]. We used their taxonomy as a foundation of our categorization.

Adilkhanov et al. presented a unique and clear categorization system for haptic devices based on wearability. This taxonomy provided a easy to understand framework, making it easier to understand the diverse range of devices and their respective applications. By grouping devices by how they're worn, they laid a clear groundwork for classifying the haptic domain. This was also easy way to us how to define the equipment in the easy way not making it too hard to understand. It is like a filter that defines what to leave out from our results.

In the work of Adilkhanov et al., they used a systematic way to define relevant papers from major academic databases, filtering for those that introduced innovative concepts or offered new insights into haptic feedback and device modifications, and that were published from 2010 - 2021.

The first survey on haptic interfaces and devices, and on their applications was written by Laycock and Day , who also examined how haptic feedback was combined with visual display devices (e.g., virtual reality walls and workbenches), so as to improve the immersive experience. This was the foundation for the combination for visual and haptic devices.

Hayward and coauthors presented a foundational classification of haptics in human-computer interfaces, covering human kinesthetic, tactile sensing, and existing haptic devices. Subsequent reviews have explored various aspects of haptic systems, including different taxonomies, design challenges, and specific device categories like wearable haptics, glove-type wearables, and haptic gloves classified by design.

Culbertson et al. delved into the technologies that simulate artificial touch sensations. Their review emphasized the design, control, and application of noninvasive haptic devices, introducing a taxonomy that categorizes these systems into three main types: graspable, wearable, and touchable. Within each category, they explored various haptic feedback mechanisms. In a related work, Wu and Culbertson innovated a haptic forearm sleeve using pneumatic actuation, which gives the wearer an illusion of lateral motion on the arm, achieved by a series of interconnected pneumatic actuators that create a continuous point of pressure.

III. Methodology

In the next sections, we describe our methodology in more detail.

A. Search Strategy

Our literature review followed a systematic approach presented by Kitchenham [2]. The first step in our methodology was to search for existing literature reviews that focus the same topic. We found the work of Adilkhanov [1]. However, there literature review is general. We in comparison want to focus on the entertainment industry specifically. Nevertheless, we used the taxonomy created by Adilkhanov as a first stepping stone to categorize our literature review. We created a carefully crafted search term. The search term was designed to encompass the relevant literature to answer our research question.

(gaming OR entertainment OR recreation OR games) AND (VR OR virtual reality OR MR OR mixed reality) AND (wearables OR controller OR devices)

B. Research Question

What are the developed devices in the last 5 years in Mixed Reality (MR) and Virtual Reality (VR), specifically focusing on entertainment?

What are the most common devices researched in the field of gaming and how could they be categorized?

C. Data Collection

We conducted our literature search by querying the IEEE Xplore library[1], a well-known online database for computer science literature. This database was chosen due to its reputation and popularity among computer science studies. The initial search yielded a total of 699 results, representing potential sources for our review.

D. Inclusion and Exclusion Criteria

To narrow down our search results, we established a set of inclusion and exclusion criteria. These criteria were designed to ensure that the selected papers were both relevant and of high quality. Our inclusion criteria consisted of factors such as the publication date, the alignment with the research topic and that a device was described in the study. On the other hand, exclusion criteria was: papers were not written in English, were duplicate publications or had less than 4 pages.

E. Title Screening

The next step involved a preliminary title screening of the 699 results. To distribute the workload efficiently, each member of our research team was assigned approximately one-third of the total results. After the title screening, 573 papers were excluded, as they did not meet our research objectives or failed to satisfy the inclusion criteria, leaving us with a reduced set of papers for further analysis.

F. Full Paper Evaluation

The remaining papers, a total of 126 articles, underwent a more thorough examination. In this phase, we evaluated the content and relevance of each paper to our research question. These assessments helped us identify the studies that would contribute with devices to our literature review.

G. Quality Assurance

To ensure the validity of our review, we implemented a process of double-checking. The papers that were included in our final selection were reviewed by another researcher of our team to confirm their suitability. Similarly, the papers that were excluded during the full paper evaluation stage were reviewed again by a different team member to reduce the risk of inadvertently excluding valuable contributions.

H. Final Selection

After our screening and quality assurance, a final set of 41 papers was identified as suitable for our literature review. These selected papers met our predefined inclusion criteria, demonstrated relevance to our research question by presenting a device related to VR.

This methodology provided a systematic and transparent approach to conducting our literature review, facilitating the selection of research papers for our analysis.

Example Figure:

[1]https://ieeexplore.ieee.org/Xplore/home.jsp

IV. Results

In this section, ...

A. Overall Overview

In our comprehensive exploration of 3D interfaces, the search term we employed was: (gaming OR entertainment OR recreation OR games) AND (VR OR virtual reality OR MR OR mixed reality) AND (wearables OR controller OR devices).

While our initial aim was to capture a holistic view of the entertainment and gaming industry, including its potential future trajectory, we also undertook a supplementary collection of health-related devices. We decided on this as even though our search term was not intended to find papers concerning health-related devices, the IEEExplore Library still provided papers in that direction. This was considered as reasonable as it would also allow as to of forecasting the evolution of 3D interfaces from the healthcare sector into the entertainment sector.

However, we did not evaluate the health-related devices in detail only included them in our broad categorization, seen in Figure..,. A few reasons underscored this decision:

Health-related devices are designed for specialized tasks. Their functionalities and implications are vast, often requiring a detailed, domain-specific understanding which differed from our primary sectors of focus.

While one of our sub goals was to forecast future trends, the sheer breadth and depth of the health domain hinted at a vast potential that would be best addressed in a dedicated study.

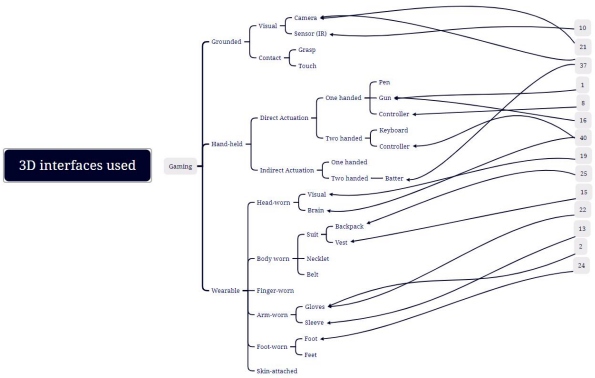
Given these considerations, we believed it was in the best interest of the study's clarity and precision to focus on the domains outlined by our original search terms: Gaming, Entertainment, and Recreation.

	Gaming	Health	Music	Entertainment
Grounded				
Grasp		[39]		
Touch			[4]	[38]
Camera	[10][21][37]			[18]
Hand-held				
Direct Actuation	[1][8][16][40]	[9][27][34]		[7][20][23][28][33]
Indirect Actuation	[37]			
Wearable				
Head-worn	[19][40]	[6][29][39]		[5][7][18]
Body-worn	[15][25]	[3][6][17]	[26][41]	
Finger-worn	[2]	[11]		[31][32][35]
Arm-worn	[13][22]	[14]		[36]
Foot-worn	[24]			[38]
Skin-attached				[12][30]

B. Gaming

In the explanation and chart for the gaming landscape we have looked at 3D interfaces, especially as they address to virtual and mixed reality. Through a detailed bottom-up approach we have categorized these interfaces based which body part used the device. Starting with the Grounded devices, think of these as the dependable tools that stay put. Which is subcategorized for Visual and Contact. "Visual" tools rely

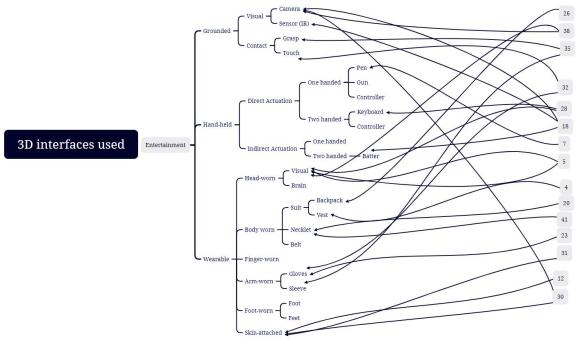
on our sense of sight, while ”Contact” ones require a hands-on approach. Then the primarily include visual gadgets like cameras and infrared sensors.



Then there is also the tactile world of Contact Interfaces, which involve direct touch or grasping actions.

Then there's the Hand-held category, the tools you can pick up and play with for example like the pens and guns. Wearable interfaces are the ones that you wear on your head, your body, or even attached to your skin. From the high-tech brain interface devices to the more common wearables for specific body parts.

C. Entertainment



D. Outstanding Devices

VR treadmill system (leap motion) coupled with a handheld 3D interface. The device is meant to be used for whole body and detect a leap when necessary. Gaming has added a new perspective on jumping over objects and it's a key movement on games these days. The sensors work simultaneously so the axis also can be changed with a little offset as well.

Haptic sensors for feet, can be used to define the motion of and placement. The sensors are meant to be used with two feet at the time but they also can be used individually for different kind of tasks.

A high-fidelity and high-precision multi-surface pen for virtual reality. With the pen the drawing does not only happen in a 2D space like we have been used to, it can also create objects and multiple different lines in 3D space making the visual outcome a lot of different compared to the normal pen that we are used to.

Soft microtubule muscle-driven 3-axis skin-stretch haptic device. The device tracks basically movement on a very high accuracy, so completing tasks with fingers like some different grips are made to be more normal and the feedback feels more like real life.

The design and implementation of a VR gun controller with haptic feedback. The gun(s) have a feedback motor and when attached to a real print of the gun added to visual devices will give the user experience like being in a real situation. Without the feedback it would feel more poor and have a lack of sensation. The motor it's self is quite simple creation but the way they have included it in a bigger entity makes it create a whole new level to the gaming.

Wack-a-mole styled hammer for games. The tool itself has a sensors, but it's also being tracked by cameras that have been grounded next to the system. The user can either see the gameplay happening on screen or by using a visual headset (VR). The second will create a more live-like experience due the high precision for it.

E. something something

The importance of subcategories becomes evident when examining user interactions. While broad categories provide an overview of interface options, the subcategories offer tailored solutions that cater to individual needs. For example, within the realm of hand-held interfaces, choices extend beyond general preferences. Some users may favor a one-handed controller due to its ergonomic design, which can minimize arm strain and align better with natural postures. Others might gravitate towards a two-handed controller, valuing its stability and comprehensive button layout. By diving into these specific nuances, we can design interfaces that not only meet functional requirements but also prioritize user comfort and intuitive use. This meticulous attention to detail ensures enhanced usability and heightened user satisfaction.

REFERENCES

[1] Adilzhan Adilkhanov, Matteo Rubagotti, and Zhanat Kappassov. Haptic devices: Wearability-based taxonomy and literature review. *IEEE Access*, 10:91923–91947, 2022.

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