Interactive Digital Display Design for Apparel Based on Virtual Reality Technology

Ning Zhu
Academy of Arts , Wuxi Taihu University , Wuxi, 214000, Jiangsu, China
zhun@wxu.edu.cn

Abstract: The conventional clothing interactive digital display method mainly uses the Eye Toy 2D optical somatosensory kit to obtain interactive actions, which is easily affected by the movement trajectory offset, resulting in poor display effect indicators. Therefore, a virtual reality technology-based method is proposed. Interactive digital display method of clothing. That is, the clothing interactive digital display process is designed, and virtual reality technology is used to generate a clothing interactive digital display center, thus completing the clothing interactive digital display. Experimental results show that the designed clothing interactive virtual reality digital display method has good display effect indicators, strong flexibility, reliability, and certain application value. It has made certain contributions to improve clothing design satisfaction and achieve digital upgrades. contribute.
Keywords: Virtual Reality, Clothing Interactive, Digitization, Display, Design.

1. INTRODUCTION

Clothing display is an important part of visual identity application design. It is not only the display of the product itself, but also the communication of brand image, cultural charm, spiritual connotation and overall style. There are various forms of clothing display, both dynamic and static. The catwalk show is one of the most intuitive and dynamic forms of clothing display. On the T stage, models wear carefully designed clothing and show the audience the style, fabric, tailoring and matching effect of the clothing through catwalks. Window display is another important form of clothing display. It mainly displays the styles and matching effects of clothing to passers-by in a static way. In the context of digitalization (Lai & Lu, 2021), clothing display methods are gradually upgrading, and interactivity is gradually valued. Therefore, it is necessary to study interactive digital display of clothing. Interactive digital display breaks the limitations of the traditional display, consumers can freely choose, match and try on clothes, to get a more personalized, immersive shopping experience. In addition, through virtual try-on and all-around display, consumers can more accurately understand the style, size and wearing effect of the clothing, thus reducing the return rate due to inappropriate sizes or styles. Digital display can quickly update clothing styles and inventory information, realize online and offline sales synchronization, improve sales efficiency and customer

satisfaction. Relevant researchers have designed several conventional interactive digital display methods for apparel display requirements. Literature (Ahmad & Ahuja, 2023) considered e-textile to adjust the style, color, material, etc., to achieve personalized customization, reducing the dependence of the display samples, but the method involves the integration of a variety of technologies, may face technical stability, compatibility and other aspects of the problem. Literature (Rabosh et al., 2023) based on the information analog-to-digital conversion of analog signals (such as clothing color, texture, material, etc.) accurately converted to digital signals, to ensure the accuracy of the clothing digital display information, but the method of the comprehensive input cost is high, and the interaction with the user's general effect. Literature (Kumar et al., 2024) using high-speed digital display of real-time interaction with the content of the clothing display, such as selecting different styles, colors, materials, etc., to enhance the user's sense of participation and satisfaction. However, this method involves a large amount of computation, and the complexity is too high. Literature (Singh et al., 2023) combined with digital marketing to collect user interaction data, in-depth understanding of consumer demand, and optimize clothing design, but the method is more dependent on equipment, and the display stability is low. Therefore, in order to meet the requirements of multi-scene display, this paper is based on virtual reality technology to optimize the design of interactive digital display of clothing.

2. OPTIMIZED DESIGN OF INTERACTIVE DIGITAL DISPLAY OF CLOTHING WITH VIRTUAL REALITY TECHNOLOGY

2.1 Designing an Interactive Digital Display Process For Clothing

The content of clothing display includes pattern clarity, color, layout, etc., which may be affected by the hardware conditions, large deviation, affecting the realism of the display (Ahn et al., 2023; Bufano et al., 2023; Hartmann et al., 2023; Macchitella et al., 2023; Oliveira et al., 2024), therefore, this paper carries out the fabric parameter setting by simulation, and designs the process of interactive digital display of clothing. Firstly, it is necessary to deal with the interactive details D_C of clothing, as shown in (1) below.

$$D_C = E_A + E_C\left(\frac{1}{N}\right)^2 \quad (1)$$

In equation (1), E_A represents the interaction parameter, E_C represents the display constant, N represents the scene dimension, based on which the

garment texture coefficients F can be calculated, as shown in (2) below.

$$F = D_C \setminus Techno\log ies \quad (2)$$

In equation (2), $Techno\log ies$ represents the display rendering factor (Hu et al., 2024; Ito & Nakanishi, 2022; Martial et al., 2023), according to the above parameters texture refinement can be performed, the objective function $f(a)$ is shown in (3) below.

$$f(a) = F\left(D_C\right) \square Direct \quad (3)$$

In equation (3), $Direct$ represents the texture overlap parameter, based on this, the generated digitized display flow is shown in Fig. 1 below.

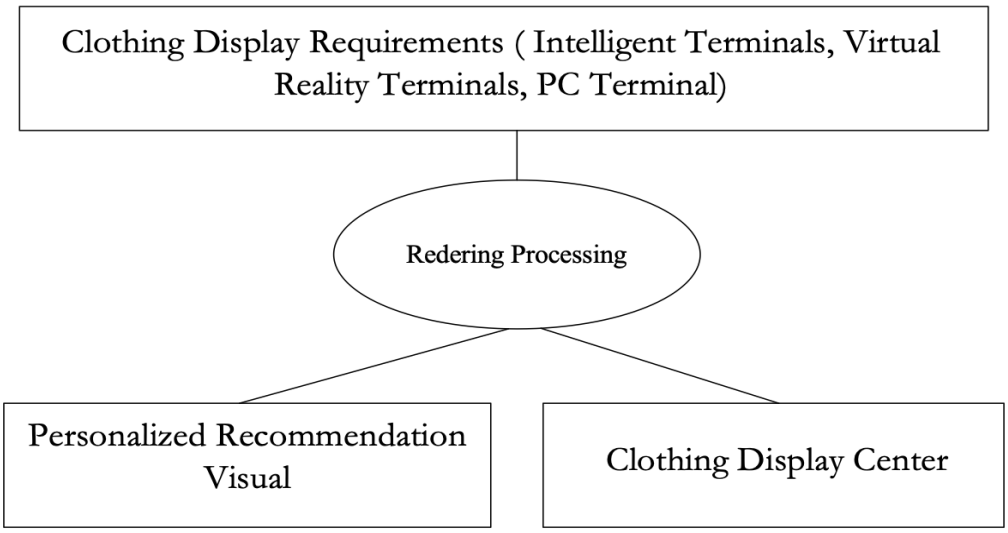


Figure 1: The digital display process

As can be seen from Figure 1, the above-mentioned digital display process can effectively carry out consumer interaction, locate clothing display requirements (Adegoke et al., 2022; Bexson et al., 2024; Lu et al., 2024; TACHIBANA & MATSUMIYA, 2022) based on effective display materials and materials, and determine the display style and theme. Then use computer-aided design (CAD) software to draw a two-dimensional pattern of the garment, and model it through three-dimensional design software (such as 3ds Max, Maya, Blender, etc.) to refine the details of the garment. It lays the foundation for creating a high-quality clothing interactive digital display center.

2.2 Generate an Interactive Digital Display Center for Clothing Based on Virtual Reality Technology

Virtual reality technology can create a virtual simulation environment to achieve a highly immersive interactive digital display, therefore, this paper

generates an interactive digital display center for clothing based on virtual reality technology (Brown et al., 2023; Korneev et al., 2022; Zhu et al., 2018). Firstly, we can create a clothing display scene PS, as shown in (4) below.

$$PS = \{EO, IoT\} \quad (4)$$

In equation (4), EO represents interactive display elements. IoT represents elements such as interactive evaluation, based on which virtual interactive display scenarios VS can be simulated, as shown in (5) below.

$$VS = \{DM, MM\} \quad (5)$$

In equation (5), DM represents the display data mapping, MM represents the display model mapping, the set DM of multidimensional twin data that may exist during the interactive display is shown in (6) below.

$$DM = \{G, P, B, R, C\} \quad (6)$$

In equation (6), G represents the geometric parameters of the garment sample, P represents the multidimensional presentation parameters, B represents the act of displaying. R represents rules for the display of delegates. C represents display realism (Alsalameen et al., 2023; Carter & Egliston, 2023; YOSHIDA et al., 2023). Virtual reality technology is the core of constructing a digital display center, which enables users to immerse themselves in a computer-generated virtual world and interact with objects in it by simulating the environment, perception, natural skills and sensing devices. Based on this, an interactive digital display center for clothing is generated as shown in Figure 2 below.

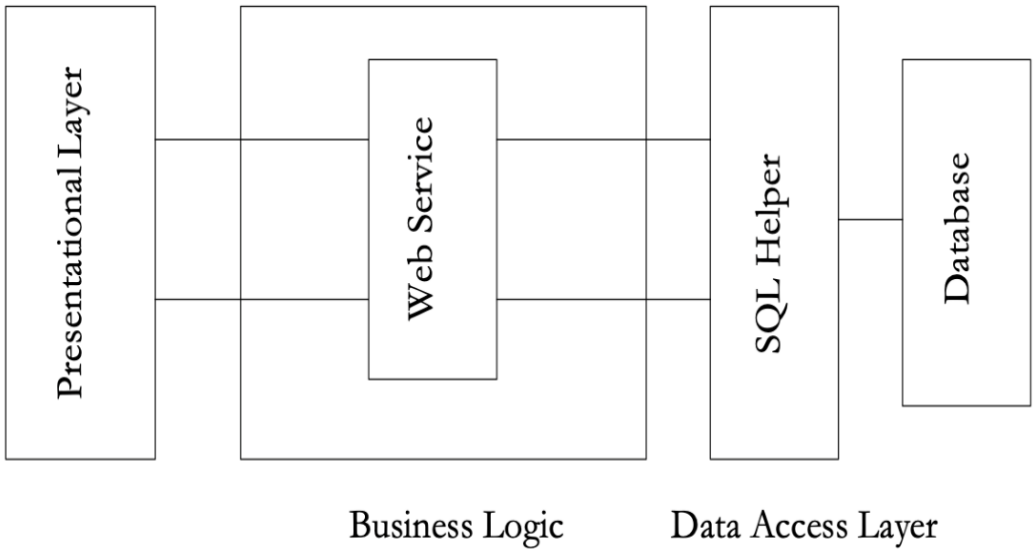


Figure 2: Interactive digital display center for clothing

As can be seen from Figure 2, the main functions of the above interactive digital display center for clothing include: clothing display: displaying a variety of clothing styles and styles in the virtual environment (Gao et al., 2024), the user can browse, search and other ways to find the clothing of interest.

Virtual Try-On: Users can choose their own virtual image and try on different clothes to see the effect of dressing. The system will adjust the fit and dynamics of the clothing in real time according to the user's body type and movement. Interactive experience: Users can interact with the costumes in the virtual environment in a variety of ways, such as rotating, zooming in, zooming out, etc. (Choi, 2022), in order to have a more comprehensive understanding of the details and features of the costumes. Personalized customization: Some systems may also support the user according to their own preferences and needs for personalized customization of clothing, such as choosing the color, pattern, material and so on. Provides users with a new way of displaying and experiencing clothing, and improves the comprehensive performance of the display.

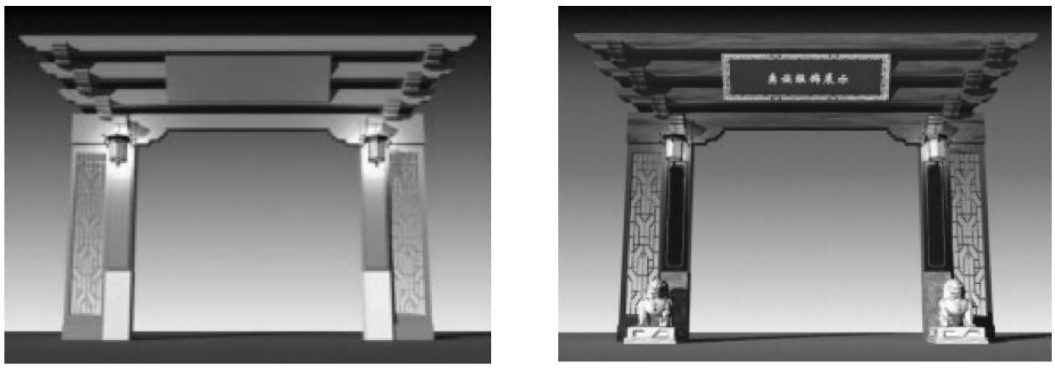
3. EXPERIMENT

In order to verify the display effect of the designed virtual reality-based clothing interactive digital display optimization design method, this paper selects an effective experimental platform and compares it with the clothing interactive digital display method based on the analog-to-digital conversion of information, as well as the clothing interactive digital display method combined with digital marketing, and conducts the experiments as follows.

3.1 Experimental Preparation

Combined with the experimental requirements for clothing interactive digital display, this paper selected the NURBS (Non-Uniform-Rational-β-Splines) surface digital modeling platform as the experimental platform and conducted Polygon modeling. That is, convert the objects to be displayed into editable objects, set nodes and boundary elements, use multi-planes to complete surface simulation, add digital display details, and avoid the problem of overlapping display textures. At this time, you need to use 3D max tools to create a three-dimensional model of clothing display, create a display repair command, and complete texture processing. The rendering

diagram of the experimental scene model is shown in Figure 3 below.

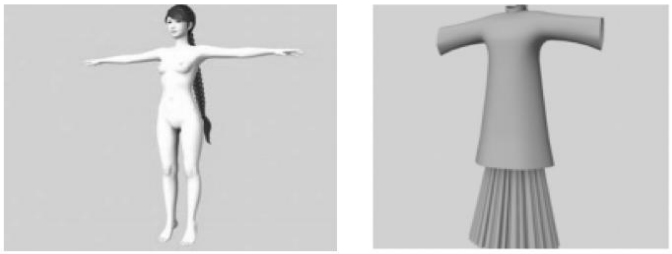


Initial Experimental Scenario

Experimental Scene After Rendering

Figure 3: Schematic rendering of the experimental scene

As can be seen from Figure 3, after the above steps are completed, it is necessary to set the clothing rendering density, draw the lofting command, adjust the hem width, and modify the clothing shape curve. After the above steps are completed, you need to divide the user character model into several parts according to the clothing to display the user characteristics, including the head, torso, etc., adjust the position of the limbs, and use Photoshop to refine the lines. The created character model is as shown in Figure 4 shown.



Character Modle

Clothing

Baking Effect

Figure 4: Role model

As can be seen from Figure 4, the above character model is mainly created based on a cube of a specified size, the detailed conditions are modified, and then a patch is created based on the density of the skirt to

implement polygon conversion to ensure that the character's appearance meets the body structure. In order to reduce the impact of randomness on the experimental results, this article performed Render To Textures texture baking, completed the pattern display in 3D MAX, obtained the Mouse Cursor System BB experimental instructions, and output reliable interactive digital display of clothing experimental results.

3.2 Experimental Results and Discussion

Combined with the above experimental preparations, this article converted the clothing to be displayed, installed Exporter.exe to export a valid display format for Tibet, exported the nmo plug-in, and input file\export into the corresponding directory. At this time, respectively, based on the design of this article, The optimization design method of virtual reality clothing interactive digital display, the clothing interactive digital display method based on information analog-to-digital conversion, and the clothing interactive digital display method combined with digital marketing for clothing interactive display, using SPSS tools to output the results of the three methods display normalized scores (0.0~1.0, the closer to 1.0, the better the display effect), the experimental results are shown in Table 1 below.

Table 1: Normalized scores for interactive digital displays of clothing

Project	**The Optimization Design Method for Interactive Digital Display of Clothing Based on Virtual Reality Designed in this Article**	**Interactive Digital Display Method for Clothing Based on Information Analog-to-Digital Conversion**	**Interactive Digital Display Method for Clothing Based on Digital Marketing**
Fabric Color	0.9542	0.5548	0.5254
Fabric Texture	0.9417	0.6142	0.5365
Fabric Luster	0.9286	0.6368	0.6984
Thickness And Texture	0.9335	0.5256	0.5152
Static Overhang	0.9984	0.6984	0.5366
Static Whole	0.9251	0.5124	0.6952
Clothing Silhouette	0.9741	0.5852	0.5841
Detailed Structure	0.9852	0.5636	0.6258
Wrinkle Effect	0.9398	0.5985	0.5222
Perspective	0.9662	0.6285	0.6369
Dynamic Overhang	0.9871	0.5171	0.5584
Dynamic Swing	0.9285	0.6253	0.6223

As can be seen from Table 1, the virtual reality-based clothing interactive digital display optimization design method designed in this article performs well in all display dimensions and achieves almost perfect results in static display. The performance of the interactive digital display method of clothing based on information analog-to-digital conversion is average in most dimensions, indicating that this method has certain limitations in the display effect. The interactive digital display method of clothing combined with digital marketing performs poorly in some key dimensions (such as fabric color, fabric texture, static draping, etc.). At this time, different clothing materials can be set and displayed using three methods. The display effect indicators output by the Virtools tool are shown in Table 2 below.

Table 2: Experimental results of display effect indicators

Method	Display Number	Clothing Style	Material Type	User Rating	Display Authenticity	Collision Monitoring Accuracy (%)	Realistic Simulation of Deformation Effect (%)
The Optimization Design Method for Interactive Digital Display of Clothing Based on Virtual Reality Designed in this Article	Exp001	Dress	Cotton Material	9.652	0.951	95.254	95.585
	Exp002	Shirt	Dacron	9.142	0.914	96.175	98.824
	Exp003	Jeans	Denim	9.368	0.923	98.233	94.145
	Exp004	Tracksuit	Polyester	9.569	0.998	95.952	92.236
	Exp005	Down Jackets	Eiderdown	9.841	0.964	92.412	96.985
Interactive Digital Display Method for Clothing Based on Information Analog-to-Digital Conversion	Exp001	Dress	Cotton Material	7.252	0.525	73.841	66.241
	Exp002	Shirt	Dacron	5.336	0.633	76.223	79.223
	Exp003	Jeans	Denim	6.541	0.598	79.969	78.872
	Exp004	Tracksuit	Polyester	5.252	0.524	78.454	75.163
	Exp005	Down Jackets	Eiderdown	6.323	0.428	75.172	74.841
Interactive Digital Display Method for Clothing Based on Digital Marketing	Exp001	Dress	Cotton Material	6.984	0.636	64.365	72.115
	Exp002	Shirt	Dacron	7.152	0.582	77.987	62.398
	Exp003	Jeans	Denim	7.332	0.617	71.145	63.248
	Exp004	Tracksuit	Polyester	6.985	0.723	62.223	76.053
	Exp005	Down Jackets	Eiderdown	7.647	0.669	73.986	78.692

As can be seen from Table 2, the optimization design method of interactive digital display of clothing based on virtual reality designed in this paper performs well in all display numbers, and the user ratings are generally high. At the same time, the display realism, collision monitoring accuracy and deformation effect simulation realism and other indicators are close to 90% or more, proving the superiority of the method. The user ratings of the interactive digital display of clothing based on analog-to-digital conversion are generally low, indicating that the method has obvious deficiencies in user experience and display effect. In addition, the display realism, collision monitoring accuracy and deformation effect simulation realism are also relatively low, especially in the display realism, which shows the limitations of the method in restoring the real texture and dynamic effect of the garments.

The user ratings of the interactive digital display of apparel combined with digital marketing are between the first two methods, indicating that the method has some improvement in user experience and display effect, but there is still room for improvement. In terms of display realism, the method is slightly higher than the information analog-to-digital conversion method, but its performance in terms of collision monitoring accuracy and deformation effect simulation realism varies and needs to be further optimized.

The virtual reality method shows high realism in all display numbers, close to or more than 0.95, showing its strong simulation ability; the information modulus conversion method and the digital marketing method are relatively low, and the display realism is generally less than 0.6. The virtual reality method performs well in collision monitoring, and the accuracy is generally more than 90%, showing its high-precision physical simulation ability; the information modulus conversion method and the digital marketing method are relatively low, but the digital marketing method performs slightly better than the information modulus conversion method in some display numbers. The virtual reality method performs well in the deformation effect simulation, and the simulation realism is generally above 90%, while the information analog-to-digital conversion method and digital marketing method are relatively low. Thus, it can be seen that the optimization design method of interactive digital display of apparel based on virtual reality designed in this paper has obvious advantages in key indexes such as user rating, display realism, collision monitoring accuracy and deformation effect simulation realism, and has certain application value.

4. CONCLUSION

Under the background of the development of computer technology and interactive virtual and augmented reality technology, our country's clothing industry is undergoing tremendous changes, and digital interactive display has gradually replaced the previous physical sample display as the main display method. Using professional 3D modeling software, you can build an accurate three-dimensional model of clothing to describe the shape, material, texture and other details of the clothing. In addition, consumers can wear VR equipment to enter the virtual environment, try on clothes immersively, and feel the wearing effect and comfort of the clothes. They can also freely rotate, zoom, and move the perspective to observe the details and wear of the clothes in an all-round way. Research shows that in complex scenarios, existing digital display technology may experience delays or freezes when processing large amounts of data, affecting the user experience. Therefore, this article designs an effective interactive digital display of clothing based on virtual reality technology. method. The experimental results show that the designed digital display method has better display effects, higher display indicators, has certain application value, and has made a certain contribution to improving the intuitiveness and immersion of clothing display.

References

Adegoke, A. S., Oladokun, T. T., Ayodele, T. O., Agbato, S. E., Jinadu, A. D., & Olaleye, S. O. (2022). Analysing the criteria for measuring the determinants of virtual reality technology adoption in real estate agency practice in Lagos: a DEMATEL method. *Property Management*, *40*(3), 285-301.

Ahmad, M. M., & Ahuja, K. (2023). E-textiles: a revolutionary technology. *International Journal of System Assurance Engineering and Management*, *14*(6), 2031-2047.

Ahn, D.-K., Bae, B.-C., & Kim, Y. (2023). User Experience of a Digital Fashion Show: Exploring the Effectiveness of Interactivity in Virtual Reality. *Applied Sciences*, *13*(4), 2558.

Alsalameen, R., Almazaydeh, L., Alqudah, B., & Elleithy, K. (2023). Information Technology Students' Perceptions Toward Using Virtual Reality Technology for Educational Purposes. *International Journal of Interactive Mobile Technologies*, *17*(7).

Bexson, C., Oldham, G., & Wray, J. (2024). Safety of virtual reality use in children: a systematic review. *European journal of pediatrics*, *183*(5), 2071-2090.

Brown, C., Hicks, J., Rinaudo, C. H., & Burch, R. (2023). The use of augmented reality and virtual reality in ergonomic applications for education, aviation, and maintenance. *Ergonomics in Design*, *31*(4), 23-31.

Bufano, P., Albertini, N., Chiarelli, S., Barone, V., Valleggi, M., Parrini, G., Tognetti, A., Cesari, V., Gemignani, A., & Menicucci, D. (2023). Weakened sustained

attention and increased cognitive effort after Total sleep deprivation: a virtual reality ecological study. *International Journal of Human–Computer Interaction*, *39*(18), 3546-3555.

Carter, M., & Egliston, B. (2023). What are the risks of virtual reality data? Learning analytics, algorithmic bias and a fantasy of perfect data. *New media & society*, *25*(3), 485-504.

Choi, K.-H. (2022). 3D dynamic fashion design development using digital technology and its potential in online platforms. *Fashion and Textiles*, *9*(1), 9.

Gao, W., Yan, X., & Li, T. (2024). Influencing Factors and Critical Paths of Virtual Reality Adoption by AEC Enterprises Based on TOE-SNA. *Journal of Construction Engineering and Management*, *150*(2), 04023162.

Hartmann, C., Orli-Idrissi, Y., Pflieger, L. C. J., & Bannert, M. (2023). Imagine & immerse yourself: Does visuospatial imagery moderate learning in virtual reality? *Computers & Education*, *207*, 104909.

Hu, L., Gao, Q., Zhang, L., Wen, Y., Gao, Z., & Wang, R. (2024). Working memory capacity for biological motion: a virtual reality examination. *Current Psychology*, 1-9.

Ito, S., & Nakanishi, Y. (2022). AmplifiedCoaster: Amplifying the Perception of Ascent and Descent in Virtual-Reality-Equipped Electric Wheelchair in an Electric Wheeled Ramp. ICAT-EGVE (Posters and Demos),

Korneev, E., Liubogoshchev, M., & Khorov, E. (2022). Studying cloud-based virtual reality traffic. *Journal of Communications Technology and Electronics*, *67*(12), 1500-1505.

Kumar, B. B., Kumar, S., Tiwari, P. K., Yadav, A. B., Dubey, S., & Singh, K. (2024). Performance Investigation of Bottom Gate ZnO Based TFT for High-Speed Digital Display Circuit Applications. *Transactions on Electrical and Electronic Materials*, 1-13.

Lai, H., & Lu, M. (2021). Dynamic VR Display System of Digital Garment Display Design Based on 5G Virtual Reality Technology. Big Data Analytics for Cyber-Physical System in Smart City: BDCPS 2020, 28-29 December 2020, Shanghai, China,

Lu, Z., Wang, W., Florez-Arango, J. F., Seo, J. H., Hamilton, D. K., & Wells-Beede, E. (2024). A framework to develop an immersive virtual reality simulation tool for postpartum hemorrhage management nurse training. *Nursing Education Perspectives*, *45*(3), 189-191.

Macchitella, L., Amendola, S., Barraco, G., Scoditti, S., Gallo, I., Oliva, M. C., & Trabacca, A. (2023). A narrative review of the use of a cutting-edge virtual reality rehabilitation technology in neurological and neuropsychological rehabilitation. *NeuroRehabilitation*(Preprint), 1-19.

Martial, C., Cassol, H., Slater, M., Bourdin, P., Mensen, A., Oliva, R., Laureys, S., & Núñez, P. (2023). Electroencephalographic signature of out-of-body experiences induced by virtual reality: A novel methodological approach. *Journal of cognitive neuroscience*, *35*(9), 1410-1422.

Oliveira, L. K. R., Marques, A. P., Andrade, K. F. A., Assis, J. C. S. d., Brito, A. L., Souza, G. S., & Callegari, B. (2024). Virtual Reality in Improving Anticipatory Postural Adjustments to Step Initiation in Individuals with Knee Osteoarthritis:

A Randomized Controlled Trial. *Games for Health Journal*, *13*(2), 100-108.

Rabosh, E. V., Balbekin, N. S., & Petrov, N. V. (2023). Analog-to-digital conversion of information archived in display holograms: I. discussion. *JOSA A*, *40*(4), B47-B56.

Singh, V., Nanavati, B., Kar, A. K., & Gupta, A. (2023). How to maximize clicks for display advertisement in digital marketing? A reinforcement learning approach. *Information Systems Frontiers*, *25*(4), 1621-1638.

TACHIBANA, R., & MATSUMIYA, K. (2022). Visual and Auditory Psychological Experiments in Virtual Reality: Accuracy and Precision of Stimulus Presentation. *Japanese Journal of Psychonomic Science*, *41*(1).

YOSHIDA, N., IIDA, S., HAGIWARA, R., & KANAZASHI, Y. (2023). Learning Effect by Motor Imagery of Catching Motion Using Virtual Reality and Observation of Surface Cerebral Hemodynamics. *Rigakuryoho Kagaku*, *38*(1), 7-13.

Zhu, X.-j., Lu, H., & Rätsch, M. (2018). An interactive clothing design and personalized virtual display system. *Multimedia Tools and Applications*, *77*(20), 27163-27179.