Virtual Reality in E-commerce: A Study

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Abstract Online shopping has made the hassles of stepping out of homes to purchase items a thing of the past. With various organizations running their businesses online and with the onset of the pandemic, relying on e-commerce sites has simplified our lives. Although these applications provide details of products through the use of images and text, consumers are still wary and skeptical about the quality or fit of a product before making the purchase. In this work, we have discussed the use of virtual reality (VR) in these applications, to create a shopping environment for the consumers from the comfort of their homes. We have also proposed an architecture framework to implement VR on e-commerce. We provide a use case of online shopping which involves a product such as apparels along with certain future research directions.

Keywords Virtual reality (VR) · Augmented reality (AR) · VR headset · Virtual embodiment (Avatar)

1 Introduction

In the era of technology and its vast use in a multitude of fields such as health care, education, and corporate sector, the average human is so highly dependent on it that they have gone way past the phase of manual or physical labor. It comes as no surprise that technology and its various advancements have made our lives so much simpler, and we rely on it every second of every day. The use of technology has expanded to various domains, and with each advancement, a new creation is introduced [1]. Data encryption, information systems, automation, artificial intelligence [1], quantum computing, etc., are just some of them. However, a rapidly flourishing and booming field is that of VR [2]. VR is a simulation generated using a computer

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where a person can experience and interact with a simulated environment which is usually presented in a 3-dimensional artificial world. VR is applied in numerous fields [3] such as gaming, entertainment, education, military training, and even health care such as medical training. According to a report by Statista Research Department, the consumer VR market is predicted to reach $3.7 billion by the end of year 2021[4]. In the field of e-commerce, which accounts for over 3.4 billion users worldwide (according to a report by CSA, Worldometer), VR is yet to burgeon. A survey by UNCTAD has found that in the unprecedented rise of the COVID-19 pandemic, the online shopping purchases have surged by 6–10 points across most product categories [5]. This rise in the growth of online shopping proves its tendency to make a huge impact in the world of e-commerce and how the introduction of VR in this field can influence it for the better. A more rigorous study of VR can make a great advancement in how consumers can shop online on e-commerce sites through a more interactive experience.

There are numerous fields where VR can be implemented in different ways to ease human work. Our motivation to delve deeper into the world of VR stems from witnessing the sudden halt of the economy in the unprecedented rise of COVID-19. We have contributed our findings and research on the concept of VR and created a design to implement this technology in the field of e-commerce.

The rest of the paper is organized as follows. In Sect. 2, we present the related works in VR and fields similar to e-commerce. In Sect. 3, we present the brief history of virtual reality, its components along with features. Section 4 describes how the e-commerce shopping is done using VR. The proposed architecture framework is given in Sect. 5. Section 6 presents a business use case scenario and workflow of the design. Finally, Sect. 7 concludes the paper.

2 Related Work

The study of VR in various fields was a popular trend in the twenty-first century. Jung et al. [6] designed a model for the use of VR in rollercoasters which was then put to test at a Finnish amusement park. They introduced the social impact by measuring user satisfaction along with VR experience in the proposed model. Another study by Carlos Flavián et al. [7] explained the impact of VR, AR, and mixed reality by combining technological (embodiment), psychological (presence), and behavioral (interactivity) views to form taxonomy "EPI Cube." In their study of the proposed system, they have clearly distinguished the theory and the applications of three different realities—AR, VR, and MR. A text-mining approach was proposed by Loureiroa et al. [8] where the authors used a Bayesian model to analyze 150 articles and study VR in marketing. They have mainly focused on two fields, i.e., tourism and retailing, where five senses have been incorporated with VR experiences so that user is willing to experience the tourism and retailing again in the future. Xi et al. [9] reviewed 72 research papers that discuss the application of VR in shopping. In the proposed study, they mentioned several implications and aspects of VR in retail systems. Based on the conducted review by the authors, 16 future research agenda were proposed in the study.

Lu et al. [10] explained the use of AR in the field of e-commerce. The authors presented a prototype for AR e-commerce system whose result showed that how customer decision-making could be improved using AR. They concluded that the proposed AR system can also be improvised by uploading images and videos for avoiding portability of laptops and other gadgets for user convenience. Jain et al. [11] discussed different techniques like 3D and 2D display, body scanners, digital signage, and multitouch technology using VR, AR, and mixed reality to enhance shopping experience for users. They not only highlighted the limitations of e-commerce but also the integration of data mining to AR/VR techniques to provide recommended solutions in shopping experience. In the literature review by Swartout [12], we saw an overview of virtual humans, its behavior and future scope. Asadi et al. [13] designed an AR/VR platform for e-commerce. They discussed the UI design, system design, and the design of an AR/VR store in their work and elaborated the relevant components of a virtual store like salesperson, store design, sales desk, products, shelves, storeowner, and showroom as all in virtual mode.

3 Virtual Reality and Its Components

The history and origin of virtual reality dates back to 1838 when Charles Wheatstone performed a research to explain how the human brain perceives the 2-dimensional image captured by each eye as one single 3-dimensional object [14]. The two images were called stereoscopic images which were coined by the word stereoscope through which these images were viewed. The stereoscope produced two separate offset images, one for the left eye and one for the right. The brain then combines both the images to create a depth which causes the viewer to see the image in three dimensions. Obviously, the stereoscope created by Charles Wheatstone as shown in Fig. 1 was slightly complicated, which was later modified into a simpler device by Sir David Brewster in 1849, where he invented a lens-based stereoscope [14].

The evolution of the stereoscope over the years paved the way for the VR headsets currently in use. In the 1950s, cinematographer Morton Heilig invented the Sensorama (as shown in Fig. 2) with a stereoscopic 3D display including various other features [15, 16]. The 1960s saw the first head-mounted VR which was also developed by Morton Heilig which was called the Telesphere Mask (as shown in Fig. 3) [16, 17]. The stereoscope invented in the 1800s laid a foundation to the currently used VR headsets which works on the same principle.

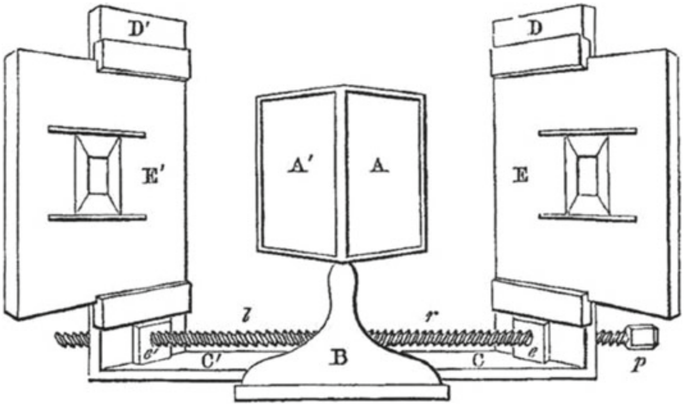

Fig. 1 Model of the stereoscope invented by Charles Wheatstone in 1838

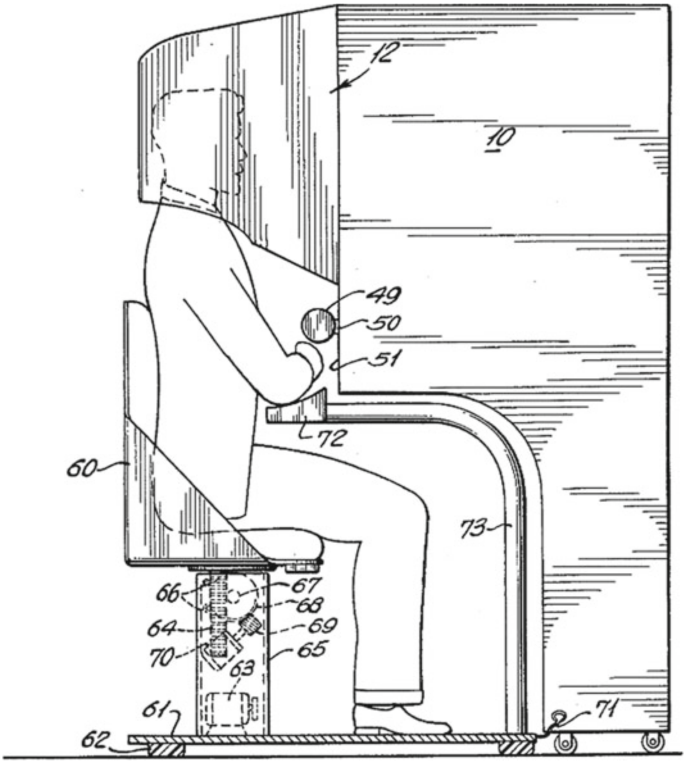

Fig. 2 Sensorama invented by Morton Heilig in the 1950s [14]

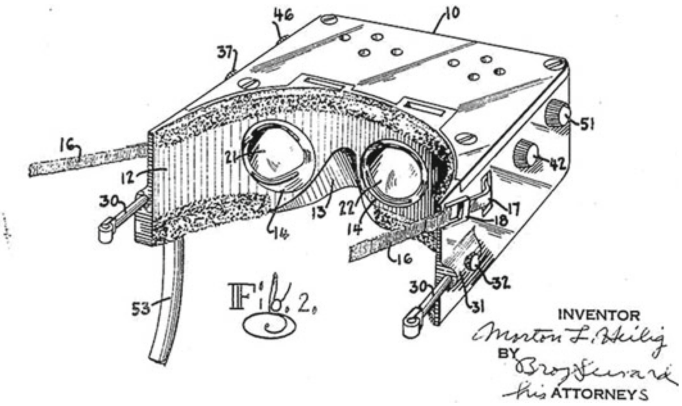

Fig. 3 Telesphere Mask invented by Morton Heilig in the 1960s [18]

3.1 Components and Features

In this section, we have presented the component used to implement VR along with their features.

3.1.1 VR Headset

E-commerce sites or mobile applications can use a VR headset to create a virtual experience for online shoppers. Understanding the working mechanism of the headset is one of the most pivotal segments in amalgamating VR and shopping apps.

A stereoscopic head-mounted display, stereo sound, and head motion-tracking sensors are components found in the headset. The head-tracking technology changes the field of vision depending on the movement [19]. It generally uses 360 degree videos. Users can use the mouse, the on-screen arrows or a Google Cardboard to look around. The Google Cardboard is a very basic VR headset device created by Google which can also be built by an ordinary person. The Cardboard Viewer can be used to experience immersion in a particular place which can be miles away from the location of the user. There are two parts in the Cardboard Viewer (as shown in Fig. 4):

1. A slot in the front where the smartphone is placed, and
2. The two glasses of plastic lenses.

The partition between the two glasses is a crucial element as it gives the user a feel of being "inside" the video, and this precipitates a 3D vision.

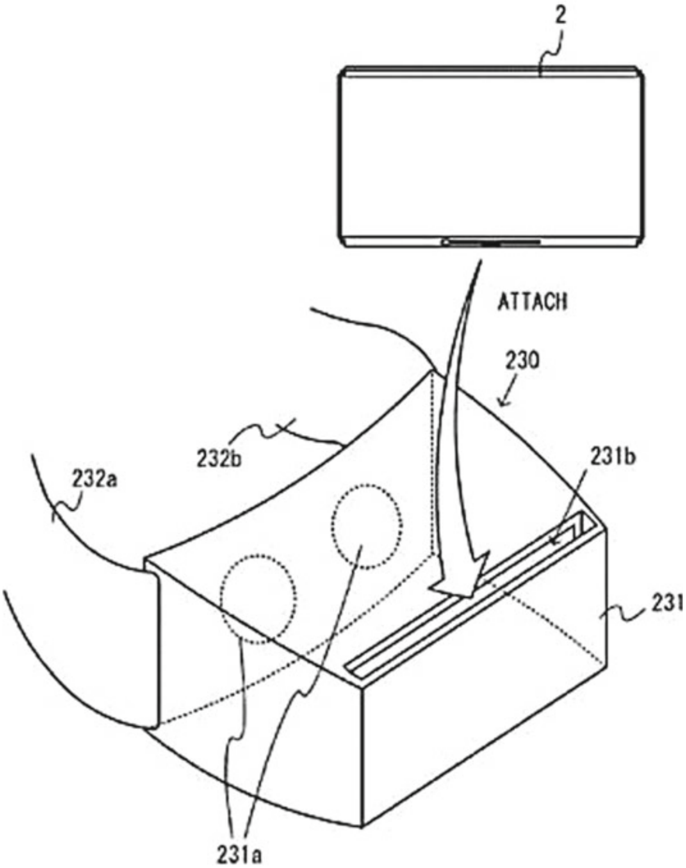

Fig. 4 Parts of a VR lens [20]

3.1.2 3D Vision

The sensation of depth from combining two slightly different pictures seen in each eye into one 3D image is called stereovision or stereopsis. When the eyes don't work together to make this 3D image, it is known as stereo blindness. Because our eyes are apart from each other by 3 inches, the view for each eye, differs in perspective. The brain merges the two views to create a sense of depth. The depth perception comes from our brain's ability to put together two 2D images to extrapolate depth. This is called stereoscopic vision [21]. Instead of using one picture, for 3D vision, two different pictures are used for each of the eyes that are slightly offset. The box hosts the image in a specific distance from the eyes and divides the images into two so that each eye focuses on the image [16]. This video uses stereoscopic display which stimulates our eyes to force our brain into believing that the image is three dimensional. The display device has a couple of sensors [22] that measures positions

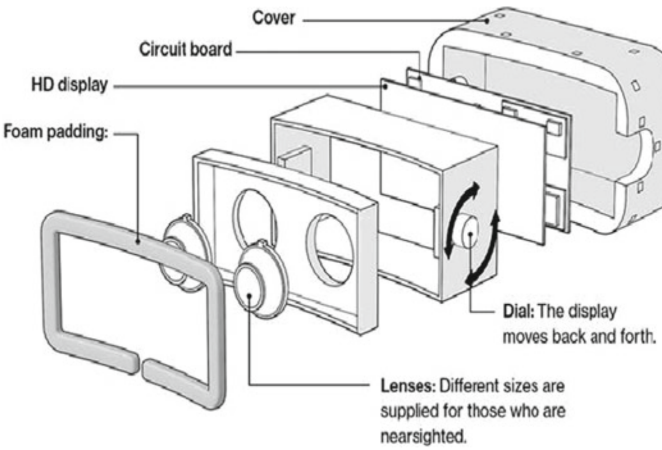

Fig. 5 Model of a modern VR headset [23]

and angle, to allow head tracking. The modern twenty-first century virtual reality headset comes with a variety of advancements and features added to it.

3.1.3 Features

Currently, VR headsets produced come with a few added features such as head tracking, motion tracking, and potentially, eye tracking.

Head Tracking

The modern VR headset as shown in Fig. 5 uses head tracking to increase immersion which is done by increasing the field of view. To display, a 360° view is highly expensive and, in most cases, unnecessary. Therefore, most headsets use a 100 or 110° view to display. The frame rate lies at a minimum of 60 frames per second. The latest headsets like Oculus have a frame rate of 90 fps, while PlayStation is capable of 120 fps. While wearing a VR headset, we want the display to change as and when we rotate our head. This is achieved through head tracking. 6DoF, which is an abbreviation for six degrees of freedom, is a system in which head tracking is performed using the three coordinate axes, X, Y, and Z. This measures head movements forward, backwards, sideways, and shoulder to shoulder. The components used in head-tracking system include magnetometer, accelerometer, and a gyroscope. To avoid a lag between head movements or display change, we need to keep a low latency which amounts to at least 50 ms.

Motion Tracking

Motion tracking in VR is still under development. A computer hardware sensor device which uses infrared sensors to track hand movements was developed by Leap

Motion which is used in Oculus dev kits. Similarly, Kinect 2 cameras can be used to track our body movements.

Eye Tracking

Like motion tracking, eye tracking is not a fully developed feature in VR headsets. But, the mechanism involves infrared sensors which track movement of your eyes in order to expand display widths required or to create depth of the field.

4 Shopping on E-commerce Sites Using VR

In the last decade, the e-commerce industry has been booming, and a majority of customers prefer shopping for products online from the comfort of their homes. While shopping through mobile applications has made our lives easier, it has several drawbacks. Users are sometimes skeptical while choosing a product only by judging its quality or fit from an image. One way to overcome this is by introducing VR in these sites so that users can see a 3D image of the product in a virtual environment. Products can range from groceries to furniture and apparels. Products under groceries include pantry, health and household, beauty, and luxury items. The application should create an environment for the customer to see the product while wearing the headset. Shopping furniture products can be made easier using VR. The customer is required to upload an image of the particular area or space where the furniture needs to be placed in the application. This image will be displayed in the virtual environment where the user can see how the particular piece would look in the room. In this work, we focus on apparel shopping in a VR environment.

4.1 Apparels

In this section, we discuss the design for shopping clothing items online.

Virtual Embodiment

Embodiment can essentially be defined as the illusion or sense of having a body. This illusion is achieved using computer-generated imagery (CGI) [15] where when the user wearing the headset looks down, sees a virtual body instead of their physical one. They see the same virtual body while looking into a mirror [24] in the virtual world. Three components of embodiment that can be considered are as follows: self-location, body ownership and agency. Self-location is when the position of our body is localized at a certain position in space. Body ownership describes the feeling or sense of the individual's "own body." For example, if the user's hand in the virtual environment is replaced with a robotic arm, it is perceived as a part of their own body in the virtual world. Agency is the feeling of "one's own actions." It describes the feeling of controlling one's own body movements by walking, running, turning, etc.

The technique used for virtual embodiment is based on CGI. It is achieved by using a VR headset and motion capture suit. The layout of the environment is divided into two sections—left and right (as shown in Fig. 6).

The virtual environment is designed in such a way that the body created using virtual embodiment is placed in front of a mirror for the user to see [24].

Right Section: On the right of the layout, there are four sections.

i. *Apparel List*: This section lists out the category of clothing, for example, trousers, t-shirts, etc. The user can select one of their preferred categories.

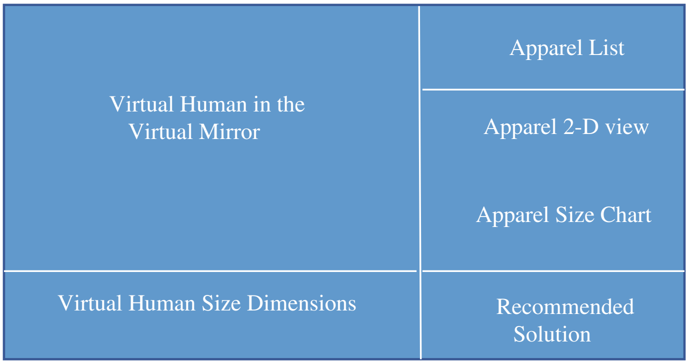

Fig. 6 Layout of VR environment view

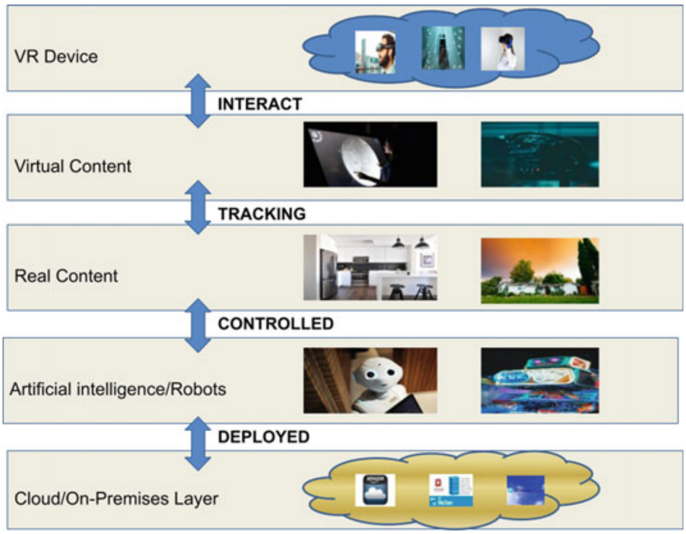

Fig. 7 Proposed system architecture

ii. *Apparel's 2D view*: A 2D image of all apparels under the above category is displayed to the user. The user can swipe through every outfit and select an apparel of his/her choice.
iii. *Apparel Size Chart*: In this section, the dimensions of the apparel as provided by the store/application are displayed in numbers to the user. This section can automatically recommend a size to the user from the input body dimensions or can also be selected manually.
iv. *Recommended items*: This section displays a collection of outfits/accessories that may complement the selected apparel. This section uses a recommendation engine like matrix factorization where the similarities are computed using content-based features [17]. While actual implementation of the system, we can use the Python language for the recommendation algorithm implementation. [25–28].

Left Section: The left side of the layout consists of the virtual human as seen in the virtual mirror, and below that we can see the dynamic body dimensions of the user.

i. *Virtual Human*: The virtual embodiment creates a virtual body using CGI. In the virtual environment, a virtual mirror is designed and placed in front of the user, and in this way, the user can see their virtual body as per the dimensions given by the user to the application.
ii. *Virtual Human Dimensions*: In this section, the user can see an animated body with the input dimensions. This is used to create a match between the user's body size and the size chart of the apparel.

The 2D image of the apparel and its size chart is coupled with the size chart of the virtual body and performs a 2D to 3D conversion of the apparel to perfectly fit the virtual body which is then available for the user to view through the VR headset. The algorithm for 2D to 3D conversion of images can be performed using multi-depth cues [29].

5 Proposed Architecture Framework

The proposed architecture framework as shown in Fig. 7 gives a brief layout of the relationship between each layer that is responsible for a VR experience. The different layers of the proposed framework are explained as follows.

Cloud/On-premises Layer: Several VR applications are employed on cloud or On-premises software. Depending on the organization's requirements, either or both of them can be used to create the VR experience. While cloud services range across the Internet and can be accessed from either public cloud or private cloud or both, On-premises software is installed locally. This is the base layer on which programs using artificial intelligence or robots are deployed.

Artificial Intelligence/Robots: The second layer of artificial intelligence or AI as we call it is an emerging field of computer science which uses machines and programs to replicate and perform the work and functionalities which is otherwise done by humans. AI requires the use of a large amount of data and algorithms to perform tasks automatically without the need for human intelligence. The data and algorithms used are deployed on the cloud/On-premises layer.

Real Content: The objects in the real world, i.e., real contents are monitored and controlled by AI and robots. This real-world content is manipulated to build the VR world.

Virtual Content: This layer involves the creation of the virtual content which is essentially what you see in your VR environment. Here, the real content is tracked and sometimes replicated to form a virtual content. This can be in any form like a video or an image.

AR/VR Devices: In the final layer, we have the physical devices used to see this virtual content. A VR headset is used to interact with the videos or images created to provide the user a 3D view of the virtual content.

6 Business Use Case and Workflow

In this section, a business use case, i.e., apparel shopping along with its workflow is presented. Apparel shopping is made quite easy where a user can just click on the 2D image of the product which pops out a 3D version of it. The user can change the perspective to view the product from different angles. For apparel shopping, the implementation of VR is required. The use case in Sect. 6.1 gives a detailed scenario of it.

6.1 Use Case: Apparel Shopping

Title: Online Apparel Shopping

Description: To purchase a t-shirt from an online store

Primary Actor: User/Customer

Pre-conditions: User is wearing the headset and can view the shopping environment having a mirror in front, a section of all apparels in the store, 2D image of the selected apparel for trial, size chart of the apparel, recommended solution consisting of complimentary apparels for the selected item. A view of the user's scaled down body dimensions are displayed below the mirror view. Selection is done using a controller/remote in hand.

Post-conditions: Environment having a list of all items added to the cart by the user. This is the checkout page.

Main Success Scenario:

Step 1: User clicks on a category from the “Apparel List” section.

Step 2: The 2D images of the apparels under the selected category are shown in the below section.

Step 3: User selects an apparel of their choice, and an enlarged image of the apparel is displayed.

Step 4: A size chart of the apparel is shown below the image displaying all the available sizes.

Step 5: The application automatically calculates the recommended size using the user’s body dimensions which can be changed manually (or) user selects the size from the size chart.

Step 6: The apparel is then displayed on the virtual human body of the user in the mirror.

Step 7: User selects the apparel by clicking the “Add to Cart” button and taps on the cart icon.

Step 8: User is then taken to the checkout page containing images of selected apparel(s).

Status: Complete.

7 Conclusion

With increasing shopping applications, the need for trustworthy, good quality products that are displayed as images to match the product received upon delivery is huge. This paper gives a detailed design of merging online shopping applications with virtual reality to create an in-person experience for consumers. The proposed ideas can simplify the shopping process for consumers who can study product features and quality factors in detail. This can thereby also avoid unwanted cancellations and returns.

References

1. https://www.engpaper.com/technology-trends-2020.htm. Accessed on 1 Dec 2021
2. Lemaignan, S., Warnier, M., Akin Sisbot, E., Clodic, A., & Alami, R. (2017, June). Artificial cognition for social human-robot interaction: An implementation, ELSEVIER (Vol. 247, pp. 45–69). https://doi.org/10.1016/j.artint.2016.07.002
3. Cipresso, P., Giglioli, I. A. C., Raya, M., Alcañiz; R., & Giuseppe. (2018). The past, present, and future of virtual and augmented reality research: A network and cluster analysis of the literature. *Frontiers in Psychology, 9*, 2086, 1–20. https://doi.org/10.3389/fpsyg.2018.02086
4. https://en.wikipedia.org/wiki/Virtual_reality_applications. Accessed on 1 Dec 2021.
5. https://www.statista.com/topics/2532/virtual-reality-vr/#dossierKeyfigures. Accessed on 3 Dec 2021.
6. https://unctad.org/news/covid-19-has-changed-online-shopping-forever-survey-shows. Accessed on 3 Dec 2021.

7. Jung, T., Claudia tom Dieck, M., Rauschnabel, P., Ascenção, M., Tuominen, P., & Moilanen, T. (2018) Functional, hedonic or social? Exploring antecedents and consequences of virtual reality rollercoaster usage, Springer International Publishing AG (pp. 247–258).https://doi.org/10.1007/978-3-319-64027-3_17
8. Flavián, C., Ibáñez-Sánchez, S., & Orús, C. (2019). The impact of virtual, augmented and mixed reality technologies on the customer experience. *Journal of Business Research, 100*, 547–560. https://doi.org/10.1016/j.jbusres.2018.10.050
9. Loureiroa, S. M. C., Guerreiroa, J., Eloyb, S., Langaroa, D., & Panchapakesanc, P. (2018) Understanding the use of virtual reality in marketing: A text mining-based review. *Journal of Business Research* (pp. 1–17). https://doi.org/10.1016/j.jbusres.2018.10.055
10. Xi, N., & Hamari, J. (2021). Shopping in virtual reality: A literature review and future agenda. *Journal of Business Research, 134*, 37–58. https://doi.org/10.1016/j.jbusres.2021.04.075
11. Lu, Y., & Smith, S. (2008) Augmented reality E-commerce: How the technology benefits people's lives. *Human Computer Interaction* 215–238.
12. Jain, S., Hada, N., & Joshi, S. (2020). Shopping using virtual reality and augmented reality. *International Journal of Advanced Science and Technology, 29*(04), 7546–7552.
13. Swartout, W.R. (2006). *Virtual Humans, American Association for Artificial Intelligence* (pp. 1543–1545).
14. Asadi, A., & Hemadi, R. (2018). Design of an AR/VR platform for e-Commerce. In: *ICTD National Conference* (pp. 1–18).
15. https://www.vrs.org.uk/virtual-reality/history.html. Accessed on 1 Dec 2021.
16. Jones, S., & Dawkins, S. (2018). The sensorama revisited: Evaluating the application of multi-sensory input on the sense of presence in 360-degree immersive film in virtual reality, Springer International Publishing AG (pp. 183–197).
17. Ogle, K. N. (1952). On the limits of stereoscopic vision. *Journal of Experimental Psychology, 44*(4), 253–259. https://doi.org/10.1037/h0057643
18. https://itnext.io/what-are-the-top-recommendation-engine-algorithms-used-nowadays-646f588ce639. Accessed on 1 Dec 2021.
19. https://www.pebblestudios.co.uk/2017/08/17/when-was-virtual-reality-invented/. Accessed on 1 Dec 2021.
20. Loomis, J. M. (2016) Presence in virtual reality and everyday life: Immersion within a world of representation, immersion within a world of representation, Massachusetts Institute of Technology, Presence (Vol. 25, No. 2, pp. 169–174). Spring. https://doi.org/10.1162/PRES_a_00255
21. https://arstechnica.com/gaming/2018/01/nintendo-is-not-hopping-on-the-vr-bandwagon-any-time-soon/. Accessed on 1 Dec 2021.
22. Wade, N. (2016). [Vision, Illusion and Perception] Art and Illusionists Volume 1, Stereoscopic Vision., https://doi.org/10.1007/978-3-319-25229-2 (Chap. 16, pp. 335–354).https://doi.org/10.1007/978-3-319-25229-2_16
23. O'Riordan, A., Newe, T., Dooly, G., & Toal, D. (2018). Stereo vision sensing: Review of existing systems. In: *2018 Twelfth International Conference on Sensing Technology (ICST)* (pp. 178–184). https://doi.org/10.1109/ICSensT.2018.8603605
24. https://blogs.ucl.ac.uk/digital-education/category/our-views/matts-musings/page/2/. Accessed on 1 Dec 2021
25. Ro, Y. K., Brem, A., & Rauschnabel, P. A. (2018). *Augmented reality smart glasses: Definition* (pp. 169–181). Springer International Publishing AG.
26. https://towardsdatascience.com/recommendation-system-in-python-lightfm-61c85010ce17. Accessed on 1 Dec 2021.
27. Parida, S., Pati, B., Nayak, S. C., & Panigrahi, C. R. (2020). Offer based auction mechanism for virtual machine allocation in cloud environment. *Advanced Computing and Intelligent Engineering*, 339–351.
28. Das, H., Naik, B., Pati, B., & Panigrahi, C. R. (2014). A survey on virtual sensor networks framework. *International Journal of Grid Distribution Computing, 7*(5), 121–130.

29. Pati, B., Misra, S., & Saha, B. K. (2012, December). Advanced network technologies virtual lab: a human-computer interface for performing experiments on wireless sensor networks. In: *2012 4th International Conference on Intelligent Human Computer Interaction (IHCI)* (pp. 1–5). IEEE.
30. Ji, P., Wang, L., Li, D.-X., & Zhang, M. An automatic 2D to 3D conversion algorithm using multi-depth cues. In: *2012 International Conference on Audio, Language and Image Processing* (pp. 546–550). https://doi.org/10.1109/ICALIP.2012.6376677