

Progress, Prospect and Challenge of VR Technology Application in the Field of Business Management

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Abstract. Business management is facing a new digital revolution. In recent years, the Internet-led information technology revolution has greatly improved management efficiency, while the Internet has also degraded the reality experience. Since late 2010, mixed reality technology has brought a new round of information technology revolution to business management by virtue of its double potential of immersion and experience. In order to deeply investigate the VR technology application in the field of business management, existing relevant researches were systematically integrated in this paper, the development and commercial application of virtual reality were summarized, and the specific application of virtual reality in the field of business management was combined.

Key words: Business management; research progress; prospect; challenge.

1. Introduction

Virtual reality (VR), as an important immersive technology, constructs three-dimensional virtual worlds through simulation, reshaping the way people interact with the real and virtual worlds [1]. Virtual reality not only has a mature application in military, medical, manufacturing, education and other professional fields, but also plays a huge commercial potential in daily life. According to statistics, 75% of the Forbes world's most valuable brands have implemented virtual reality marketing layout, and virtual reality is widely used in marketing research, product development, advertising and terminal retail in business management. [2] For example, Nestle and Walmart use virtual reality to simulate marketing research scenes to capture customers' preferences for products [3]; Ford and Volkswagen adopt virtual reality to simulate product testing scenes to deeply understand customers' specific needs for product attributes; Coca-Cola, Virgin Holidays and L'Oreal provide consumers with virtual reality brand experience to deliver brand knowledge and spirit to them; [4] Ali Buy+ uses virtual reality to simulate commodities and shopping scenes, enabling customers to get a real experience similar to offline shopping. [5]

2. Development and commercial application of VR technology

The concept of virtual reality has a long history, and the maturity of other technologies such as computer science is driving VR technology development and the industry. Looking back on the development of VR technology, it can be roughly divided into four stages: concept germination, technology exploration, breakthrough development and industrial application. With a series of landmark events as the boundary, virtual reality has seen a milestone development from technology research and development to industrialization, with distinct stage development characteristics.

2.1 VR technology 1.0 -- concept germination

The conception of VR technology emerged in the 1930s and was still in the establishment stage of conceptual terms until the 1960s. The idea of virtual reality first appeared in a 1935 science-fiction short story by S. G. Weinbaum, who described the protagonist Pygmalion's strange experience of entering another world after wearing special eyeglasses. [6] It was also the first description involving auditory, visual and tactile sensory experiences in virtual reality, and he was a visionary in the field of virtual reality.

Until 1957, cinematographer M. L. Heilig put this idea into practice and developed the "SENSORAMA" simulator. The predecessor of what is now known as the Head Mounted Displays (HMD) appeared in 1961. Philco engineers C. P. Comeau and J. S. Brian developed a simple motion-

tracking head-mounted display known as “Headsight”. [7] Connected to closed-circuit television, with display screens and tracking systems, “Headsight” aims to train military personnel for tasks such as high-speed aircraft landings and chemical hazard testing, pioneering the use of VR technology for learning and training. Based on the “SENSORAMA” simulator, Haley developed it into a “SENSORAMA” video system in 1962 and successfully applied for a patent. It can stimulate the user’s senses with external devices such as stereo speakers, three-dimensional displays and vibrating chairs. [8] It was never commercialized, but many subsequent virtual reality-related technology inventions are based on this for extension research.

In 1968, computer graphics pioneer I. E. Sutherland first developed a head-mounted display connected to a virtual environment, dubbed the “Sword of Damocles” because of its similar shape. [9] “SENSORAMA” and “Sword of Damocles” have one thing in common that they allow users to experience virtual environments using different senses, but do not support them to interact with virtual environments.

2.2 VR technology 2.0 -- technology exploration

The acceleration of VR technology in the 1970s and 1980s, when optical technology and other tactile devices developed in tandem, made it possible for users to move and interact in virtual spaces. By integrating interactive art and virtual reality experience, computer artist M. W. Krueger developed “VIDEOPLACE” in 1975, the first interactive virtual reality platform, where a series of interactive experiences were called “Artificial Reality” concept by him. [10] Instead of wearing a head-mounted display directly, “VIDEOPLACE” uses a projector and camera to interact. In 1985, S. S. Fisher, a researcher with NASA, started the Virtual Interactive Environment Workstation (VIEW) project, in a bid to make remote operation of the space station possible. [11] Relying on NASA’s strong scientific foundation and strength, VIEW project has made a lot of progress under Fisher’s leadership, spearheading the development of key virtual reality technologies such as three-dimensional audio technology and head-coupled display technology. In 1986, III. T. A. Furness devised a flight simulator called the super cockpit. [12] Innovations in the training cockpit include computer-generated 3D maps, advanced infrared and radar imagery allowing the pilot to see and hear in real time, and helmet-tracking systems and sensors allowing the pilot to control the aircraft using hand gestures, voice and eye movements. Even with significant technological advances, there was no general term to describe the field until J. Lanier first coined the term “virtual reality” in 1987. [13] As the founder of Visual Programming Lab (VPL), he was committed to developing virtual reality devices such as data gloves and videophone head-mounted displays, and his company was the first one to sell virtual goggles and gloves. The concept of virtual reality was defined and recognized by all circles.

2.3 VR technology 3.0 -- breakthrough development

The breakthrough in VR technology came between the 1990s and 2010. J. Waldern first demonstrated “Virtuality”, a virtual reality arcade machine, at the 1990 International Computer Graphics Conference in London, where users could obtain an immersive gaming experience in a 3D environment. In 1991, video game giant Sega announced the completion of the Sega VR headset, but the device was never released to the public. [14] Nevertheless, Sega has made a big contribution to popularizing virtual reality, with engineers working on hardware to push the boundaries of technology and reduce production costs while maintaining a quality virtual experience. In 1992, C. Cruz-Neira et al. utilized then-available technology to build a virtual reality environment CAVE, successfully overcoming user skepticism and an audience centric perspective. [15]

CAVE is a cube surrounded by a display screen that shows correct perspective and stereoscopic projection as the viewer moves along the path within limits. Nintendo introduced a three-dimensional video game console called “Virtual Boy” in 1995. [16] However, the technological level and the forward-thinking designers failed to match. Due to the lack of software support, the console was withdrawn from the market after only six months because it failed to meet sales expectations. VR

technology application has expanded from military and entertainment fields to medicine. In 1999, B. O. Rothbaum and other researchers proposed using VR technology to create war zone scenarios for Vietnam veterans to help treat their exposure to post-traumatic stress disorder (PTSD). [17] In the 21st century, benefiting from the breakthrough of graphics processing, motion capture and other related technologies, the research of VR technology has ushered in a rapid development stage. In 2007, Google introduced street view, combining street images with maps to display street-level images naturally. [18] Also, the company introduced 3D street view images in 2010 to make navigation easier. Virtual reality is advancing rapidly at this stage, and theory and technology synchronously span a larger range.

2.4 VR technology 4.0 -- commercial application

Since 2012, the industrialization of VR technology has entered a new stage. The market response of consumer virtual reality products in this stage is strong, and VR technology is becoming increasingly mature to make its industrial application possible. In 2012, Google launched the virtual reality glasses device “Google Glass”, while Oculus released the virtual reality headset display “Oculus Rift”. The two companies were competing in virtual reality, setting off a new wave of VR technology. In 2014, the Internet giant Facebook bought Oculus in its entirety for \$2 billion, and CEO Mark Zuckerberg deemed Oculus as the communication platform of the future, predicting that VR technology will transform the personal cyberspace experience. [19]

The acquisition marks the beginning of Internet companies’ foray into virtual reality, a technology that has captured global attention as an economic driver. In the same year, Samsung Gear VR and Google Cardboard were rolled out, increasing the availability of VR devices and facilitating users to widely explore the possibilities of VR technology. Then, in 2016, HTC began selling the HTC Vive and SONY launched the Play Station VR. The most competitive leading products in virtual reality head-mounted display equipment have all appeared, and the momentum of competition in the industry was highlighted. The year of 2016 was also regarded as a key year for the development of VR technology. In 2018, Walmart began experimenting with using VR technology for employee training, selecting 10 pilot stores and investing 17,000 Oculus headsets in the future to make virtual reality training standard in all units. [20] Walmart is one of the largest retail chain enterprises in the United States, and the decision will lift the VR technology application to a high level. The VR technology application is expanding, and its social and economic value is deeply explored.

3. VR technology application in the field of business management

3.1 Virtual reality marketing

Virtual reality marketing, as a new research field of marketing, is still in the exploratory stage. Virtual reality marketing refers to the VR technology application in marketing activities. In different marketing situations, the interaction and communication between customers and enterprises can be improved by improving the information presentation of products, enterprises and brands, so as to enhance the practical value and experience value obtained by customers. Meanwhile, enterprises can gain growth in sales volume, market share, customer equity and brand equity, namely realizing the co-creation of enterprise and customer value (see Figure 1).

Virtual reality has created great value for both customers and enterprises by improving the presentation of marketing information and interaction manner. From the perspective of customers, virtual reality marketing not only brings practical value such as increasing product knowledge, reducing product risk, as well as improving task completion efficiency and memory performance, but also creates experience value from sensory, emotional, cognitive, behavioral and social aspects. For enterprises, virtual reality marketing not only improves the performance of enterprise value activities, but also brings about sales volume, market share, customer equity and brand equity for enterprises through its positive influence on consumers’ purchase intention and participation intention.



Fig. 1 Virtual Reality Marketing and Value Co-Creation Process

First of all, virtual reality marketing has the characteristics of high simulation. In virtual reality marketing, customers cannot perceive the difference between the real environment and the virtual environment, because virtual reality can construct a virtual world with “no difference” from the real world through the computer system, and realize the dual perception of physical and psychological immersion of users. In addition, virtual reality marketing is highly experiential and can provide multi-sensory interaction. Virtual reality can integrate visual, auditory, olfactory, tactile and other sensory information to vividly depict the real product and its marketing environment. Moreover, customers can interact with the virtual reality environment through virtual reality equipment. This interaction is dynamic and autonomous, so customers can get more natural, richer and closer to the real experience than other media (such as TV, computer display screen, etc.).

3.2 Product development management

The combination of product development and virtual reality can improve the external validity of product development and serve the value design activities of enterprises. Three-dimensional simulation can provide consumers with details or internal structure information that is not easily perceived [21]. More importantly, virtual reality can simulate consumers’ experience when using products through a variety of sensory technologies, such as using olfactory display technology [22] to simulate the smell of products [23], as well as force feedback technology (haptics) to simulate consumers’ touch sensation when interacting with products, and simulate consumers’ emotions and feeling when using products [24].



Figure 2. VR Mask Developed by Feelreal

The above experiences can help enterprises design and test product attributes more specifically. Furthermore, virtual reality can be used to develop new services and test service prototypes, transforming intangible and volatile services into a nearly real experience that can be perceived [25]. However, product and service prototypes are still largely provided by enterprises, and users can only passively evaluate the prototypes. Virtual reality actually has the untapped potential to empower consumers and provide a more efficient means of interaction for collaborative innovation between enterprises and consumers.

3.3 New retail of virtual reality

Finally, VR technology can be combined with retail to realize the value transfer of business. Virtual reality can realize customers' remote trial of products and improve their experience of shopping scenes. Whether it is "virtual test run" [26], "virtual house viewing" [27], or observing its collocation in advance when buying furniture [28], virtual reality enables customers to virtually "feel, touch and try" products and experience the use effect of products in advance without actually touching them [29]. Virtual reality marketing can give customers the information they need to make purchase decisions in the pre-purchase stage, reduce the uncertainty of their perception, reduce the cost of product trial, improve their purchase intention and reduce the return rate of products. More importantly, compared with traditional online stores, virtual reality stores can provide customers with shopping experience closer to the real situation, such as walking, observing and selecting products, so as to improve the efficiency of their shopping decisions and enjoyment experience during shopping [30].

4. The prospect and challenge of VR technology application in the field of business management

As technology advances and software and hardware become more accessible, a growing number of industries will get insight into the advantages carried by VR technology. With the rapid development of the technology, its applications in various fields are expanding rapidly to seize competitive advantages. Virtual reality devices are a key part of where the technology is heading, and that trend is set to continue. VR technology will continue to develop until it enters the home and becomes an everyday object. Although its prospect is vast, its development still faces some problems.

First of all, VR technology is still in development, and there remains a certain distance between virtual reality simulation and real marketing scenes. Consumers' perception of how virtual reality can replace the real world is an important factor affecting their acceptance of virtual reality commercial marketing [31].

Second, the multi-sensory experience of virtual reality marketing does not always lead to positive results. The increase in the breadth and depth of information may aggravate the cognitive load of consumers, and thus have a negative impact on their experience of presence [32], which may also lead to their memory performance in virtual reality being lower than that of traditional media [33]. Besides, for the tourism destination marketing with experience as the main marketing object, the experience of products in advance through virtual reality in the pre-purchase stage will make consumers feel bored, thus reducing their purchase intention to products in the purchase stage.

Finally, the potential ethical issues in virtual reality marketing deserve further attention. Some consumers have reported temporary dizziness, blindness and discomfort after trying on head-mounted displays, with the physical problems caused by technology becoming more prominent among the elderly. Therefore, the ethical issues that may arise in virtual reality marketing should be considered in future research as well.

References

- [1] Dzardanova E, Kasapakis V, Gavalas D. Affective impact of social presence in immersive 3D virtual worlds[A]. Proceedings of 2017 IEEE symposium on computers and communications[C]. Heraklion, Greece: IEEE, 2017.
- [2] Ploydanai K, van den Puttelaar J, van Herpen E, et al. Using a virtual store as a research tool to investigate consumer in-store behavior[J]. Journal of Visualized Experiments, 2017, 125: e55719.
- [3] Lee K C, Chung N. Empirical analysis of consumer reaction to the virtual reality shopping mall[J]. Computers in Human Behavior, 2008, 24(1): 88-104.
- [4] Roettl J, Terlutter R. The same video game in 2D, 3D or virtual reality-how does technology impact game evaluation and brand placements? [J]. PLoS One, 2018, 13(7): e0200724

- [5] Tie Bing, Chen Yunai. Research on the layout of VR industry in China[J]. Guangdong Communication Technology, 2018, 38(03): 5-9.
- [6] Weinbaum, S. G. Pygmalion's Spectacles[M]. Auckland: The Floating Press, 2012.
- [7] Comeau, C. P., Brian, J. S. 'Headsight Television System Provides Remote Surveillance'[J]. Electronics, 1961, 10(6): 86-90.
- [8] Heilig, M. L. 'Sensorama Simulator: U.S. Patent 3,050,870'[P]. 1962-08-28.
- [9] Sutherland, I. E. 'A Head-mounted Three Dimensional Display'[A], ACM (Ed.) 1968 Fall Joint Computer Conference[C], New York: ACM Press, 1968, 757-764.
- [10] Krueger, M. W., Gionfriddo, T., Hinrichsen, K. 'VIDEOPLACE—An Artificial Reality'[J]. ACM SIGCHI Bulletin, 1977, 16(4): 35-40.
- [11] Fisher, S. S. 'Virtual Interface Environment' [EB/OL]. <https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19880014769.pdf>. 2019-03-13
- [12] Furness, III. T. A. 'The Super Cockpit and Its Human Factors Challenges'[A], Proceedings of the Human Factors Society Annual Meeting[C], Los Angeles, CA: SAGE Publications, 1986, 30(1): 48-52.
- [13] Lanier, J. 'Virtual Reality: The Promise of the Future'[J]. Interactive Learning International, 1992, 8(4): 275-279.
- [14] Sega, R. 'Sega VR'[EB/OL]. https://segaretro.org/Sega_VR. 2019-04-11.
- [15] Cruz-Neira, C., Sandin, D. J., DeFanti, T. A. 'The Cave: Audio Visual Experience Automatic Virtual Environment'[J]. Communications of the ACM, 1992, 35(6): 64-73.
- [16] Boyer, S. 'A Virtual Failure: Evaluating the Success of Nintendo's Virtual Boy'[J]. The Velvet Light Trap, 2009 (64): 23-33.
- [17] Rothbaum, B. O., Hodges, L., Alarcon, R. 'Virtual Reality Exposure Therapy for PTSD Vietnam Veterans: A Case Study'[J]. Journal of Traumatic Stress: Official Publication of The International Society for Traumatic Stress Studies, 1999, 12(2): 263-271.
- [18] Vincent, L. 'Taking Online Maps Down to Street Level'[J]. Computer, 2007, 40(12): 118-120.
- [19] CBR Staff Writer. 'Facebook Bets on Gaming Future with \$2bn Oculus Acquisition'[EB/OL]. <https://www.cbronline.com/enterprise-it/software/facebook-bets-on-future-with-2bn-virtual-reality-startup-acquisition-260314-4203654/>. 2019-04-13.
- [20] ARPost. 'Key News and Events in the Augmented and Virtual Reality Technology World-September 2018'[EB/OL]. <https://arpost.co/2018/09/28/key-news-and-events-in-the-augmented-and-virtual-reality-technology-world-september-2018/>. 2019-04-14.
- [21] Lee K C, Chung N. Empirical analysis of consumer reaction to the virtual reality shopping mall[J]. Computers in Human Behavior, 2008, 24(1): 88-104.
- [22] Bordegoni M, Carulli M. Evaluating industrial products in an innovative visual-olfactory environment[J]. Journal of Computing and Information Science in Engineering, 2016, 16(3): 030904.
- [23] Baus O, Bouchard S. Exposure to an unpleasant odour increases the sense of presence in virtual reality[J]. Virtual Reality, 2017, 21(2): 59-74.
- [24] Serrano B, Botella C, Baños R M, et al. Using virtual reality and mood-induction procedures to test products with consumers of ceramic tiles[J]. Computers in Human Behavior, 2013, 29(3): 648-653.
- [25] Bae D J, Leem C S. A visual interactive method for service prototyping[J]. Managing Service Quality, 2014, 24(4): 339-362.
- [26] Lee K C, Chung N. Empirical analysis of consumer reaction to the virtual reality shopping mall[J]. Computers in Human Behavior, 2008, 24(1): 88-104.
- [27] Juan Y K, Chen H H, Chi H Y. Developing and evaluating a virtual reality-based navigation system for pre-sale housing sales[J]. Applied Sciences, 2018, 8(6): 952-963.
- [28] Mahdjoubi L, Koh J H, Moobela C. Effects of interactive real-time simulations and humanoid avatars on consumers' responses in online house products marketing [J]. Computer-Aided Civil and Infrastructure Engineering, 2014, 29(1): 31-46.
- [29] Suh K S, Chang S. User interfaces and consumer perceptions of online stores: The role of telepresence[J]. Behaviour & Information Technology, 2006, 25(2): 99-113.

- [30] Lau K W, Lee P Y. Shopping in virtual reality: A study on consumers' shopping experience in a stereoscopic virtual reality[J]. Virtual Reality, 2018,
- [31] Guttentag D A. Virtual reality: Applications and implications for tourism [J]. Tourism Management, 2010, 31(5): 637-651.(Spielmann and Mantonakis, 2018).
- [32] Roettl J, Terlutter R. The same video game in 2D, 3D or virtual reality-how does technology impact game evaluation and brand placements?[J]. PLoS One, 2018, 13(7).
- [33] Liu C L, Uang S T. Effects of depth perception cues and display types on presence and cybersickness in the elderly within a 3D virtual store[J]. Journal of Ambient Intelligence and Humanized Computing, 2016, 7(6): 763-775.