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Original article

Immersive Virtual Reality: the Evolution of Interactive Experience

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Abstract
Research is focused on immersive virtual reality (iVR) to understand its key components and their impact on user experience. The goal of this research was to analyze the components of iVR (visual, auditory, interactive, haptic components, sensors and computing power) and their role in creating an immersive environment. The research methodology consisted of a review of the relevant literature, an analysis of existing technologies and their characteristics, as well as research into the application of iVR in various fields. The research results showed that visual elements, sound effects, interactivity, haptic feedback, sensors and computing power are key to creating an immersive experience in iVR. The analysis highlighted the importance of synchronizing these elements in order to achieve a high level of reality and presence in the virtual world. The conclusion of the research confirms that immersive virtual reality is a complex combination of technologies and elements that together create an authentic experience. These results indicate a constant need for further development of all components of iVR in order to improve the user experience and expand the possibilities of application of this technology in various fields, such as education, health, industry and entertainment.

Keywords: Immersive Virtual Reality, Immersive, Virtual Reality

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Оригинальная статья

Иммерсивная виртуальная реальность: эволюция интерактивного опыта

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Аннотация
Исследования сосредоточены на иммерсивной виртуальной реальности (iVR), чтобы понять ее ключевые компоненты и их влияние на пользовательский опыт. Целью данного исследования было проанализировать компоненты iVR (визуальные, слуховые, интерактивные, тактильные компоненты, датчики и вычислительные мощности) и их роль в создании иммерсивной среды. Методика исследования состояла из обзора соответствующей литературы, анализа существующих технологий и их характеристик, а также исследования применения iVR в различных сферах. Результаты исследования показали, что визуальные элементы, звуковые эффекты, интерактивность, тактильная обратная связь, датчики и вычислительная мощность являются ключом к созданию захватывающего опыта в iVR. Анализ подчеркнул важность синхронизации этих элементов для достижения высокого уровня реальности и присутствия в виртуальном мире. Заключение исследования подтверждает, что иммерсивная виртуальная реальность представляет собой сложное сочетание технологий и элементов, которые вместе создают аутентичный опыт. Эти результаты указывают на постоянную необходимость дальнейшего развития всех компонентов iVR с целью улучшения пользовательского опыта и расширения возможностей применения этой технологии в различных сферах, таких как образование, здравоохранение, промышленность и развлечения.

Ключевые слова: иммерсивная виртуальная реальность, иммерсив, виртуальная реальность

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Introduction

Immersive Virtual Reality (iVR) is a revolutionary technology that has fundamentally changed the way we experience the digital environment. iVR permeates our everyday life, providing a fascinating experience of total immersion in a digitally created environment. This technology has caused a fundamental transformation of our perception of reality, opening the door to new possibilities, but despite its revolutionary possibilities, iVR brings a number of key problems that require thorough research and analysis.

1. One of the most important aspects is understanding the impact of iVR on human health and well-being. While the technology allows users to fully immerse themselves in a simulated environment, there are concerns about the psychological and emotional effects. Issues related to prolonged use, relationship with reality, and potential mental health consequences require more detailed analysis.
2. iVR raises questions about ethics and privacy. In a world where technological interaction is becoming ubiquitous, understanding and regulating issues such as data protection, information manipulation and moral responsibility in the use of this technology are becoming crucial.
3. Availability of iVR remains limited due to high technology costs, insufficient infrastructure and technical barriers. Expanding the use of iVR requires innovative solutions to make the technology more accessible to the general population.

This paper will explore these issues and research directions, looking at the current state, challenges and potential perspectives in order to better understand the implications and opportunities of immersive virtual reality in today's world.

Research methodology

Immersive Virtual Reality (iVR) research methodology often includes several key steps to create a comprehensive understanding of this technology and its applications in various fields.

A review of relevant literature is a step that includes a systematic research and review of existing literature from various scientific disciplines, including computer science, psychology, medicine, engineering, and others. The goal is to identify key topics, technological trends, previous research and applications of iVR. After reviewing the literature, the next step is a detailed analysis of existing iVR technologies, hardware, software and their characteristics. Various platforms, devices, sensors, software tools, and their capabilities and limitations are explored here. After the analysis, the research focuses on the applications of iVR in various domains such as education, healthcare, military industry, entertainment, architecture, marketing, and other fields. Here, specific case studies, experiments, or real-world applications of iVR are explored to understand the effectiveness, benefits, and challenges in each of these areas. Key literature sources for this research may include scientific journals dealing with technology, medicine, education, engineering, as well as conference publications dedicated to VR technology. Also, analysis of existing technologies is often based on manufacturer documentation, technical specifications, and device reviews.

This approach provides a comprehensive overview of iVR technology, its features and applications, providing a deeper understanding of how these technologies work and how they can be applied in different sectors of society.

Immersive virtual reality

Definition of basic terms

Definition of iVR: iVR is a computer-generated simulation of three-dimensional images or environments that can be interacted with through specialized electronic equipment. This technology allows users to engage with the digital world in a manner that feels realistic or physical.

Virtual Reality (VR): Virtual reality represents an artificially created environment through software that users accept as reality. It suspends the user's disbelief, giving them a sense of being in a real environment.

Immersive (Immersing): Immersion refers to technology or imagery involving one or more senses, deeply impacting the user. This may lead to changes in mental state, providing information or stimulation for multiple senses, not just sight and sound.

Virtual Reality (Cyberspace): The term cyberspace relates to various forms of linking technical systems with the human body. It's a process transforming the real world into a virtual technological realm.

New Technological Reality: This new reality is characterized by compressing time and space into immediate information, as well as transcending human biological limitations through connections to cybernetic systems.

Revised Definition of iVR: Immersive virtual reality (iVR) is a medium consisting of interactive computer simulation. It enables users to sense their position and actions within the simulation, creating a sense of mental presence in it.

iVR refers to sophisticated technology involving real-time simulation and interaction through multiple sensor channels. It tracks users in a virtual space in real-time.

iVR allows immersion into a computer-generated world, providing a sense of interaction with 3D objects. Control and interaction with the virtual environment are akin to those in the real world.

Evolution of immersive virtual reality

The history of immersive virtual reality (iVR) is akin to an evolution story – full of innovations, discoveries, and advancements that have shaped our perception of the digital world. Its origins trace back to the 1860s when panoramic pictures, which are precursors to iVR, first emerged. However, the real momentum happened in the 20th century. French artist and writer Antonin Artaud was among the first to describe theater as „virtual reality" back in 1938, depicting how characters and objects assume incredible forms in internal dramas. Nevertheless, the term „artificial reality" was first coined by Myron Krueger in the 1970s.

The development of iVR was marked by a series of innovations. Morton Heilig conceptualized the "Experience Theatre" in 1950 to effectively engage the senses. This was followed by the creation of the Sensorama prototype in 1962, engaging multiple senses through short films, and the first visual flight simulator in 1966 for the US Air Force. Ivan Sutherland, a pioneer in computer graphics, along with his student Bob Sproull, developed the first "head-mounted display" (HMD) for virtual reality in 1968. The device, called the "Sword of Damocles," weighing about 45 kg, although primitive, was the first step toward creating a virtual world as it provided the feeling of looking through a window into a virtual space. Throughout the 60s and 70s, various institutions such as MIT and Stanford re-

searched the basics of VR, developing concepts of interactivity and immersive environments.

Jaron Lanier first used the term "virtual reality" between 1980 and 1982. This term was also used in Damien Broderick's book "Judas Mandala" in 1982, while novels like William Gibson's "Neuromancer" from 1984 set the foundation for the future development of VR. In 1984, VPL Research, founded by Jaron Lanier, commercialized early VR concepts. They introduced the "DataGlove" and "EyePhone" as peripheral devices for VR.

The earliest definition of the term "virtual reality" in the Oxford English Dictionary dates back to 1987, but the real popularization of the concept occurred through movies like "Brainstorm" and "The Lawnmower Man." By the early 1990s, interest in iVR was spreading. Howard Rheingold's book "Virtual Reality" from 1991 helped popularize this concept, attracting researchers and enthusiasts.

The further development of iVR was marked by a series of events, including the release of the first mass-produced multiplayer entertainment VR system and the creation of the first "cubic" visual space. The first mass-produced VR gaming device, Virtuality, emerged in 1991, providing an incredible experience through stereoscopic headsets, sound, and sensor-equipped gloves. Innovations continued with a telepresence system designed for driving NASA's Mars rover, the creation of the first real VR urban environment, and an artistic piece that connected two continents in real-time. In 1995, Nintendo introduced the Virtual Boy, their VR device. Although it failed in the market due to technological limitations at the time, it influenced future developments.

The development of hardware such as GPUs, sensors, and advanced screens dramatically improved the performance of VR and AR devices. Additionally, the development of software, such as tools for creating immersive experiences, contributed to the widespread use of this technology. VR and AR found applications in gaming, medicine, education, entertainment industry, tourism, architecture, and other fields. These technologies are transforming the way we learn, work, entertain ourselves, and interact with the real world.

The present reality brings new products and technological innovations. During the 2010s, major companies like Facebook, Google, and Sony invested significant amounts of money in VR technology, leading to the creation of products like OculusVR, Morpheus VR HMD, and Cardboard. Investments continued through projects like Magic Leap and others. In 2012, Oculus VR launched a Kickstarter campaign for Oculus Rift, which became known as the first modern VR headset. Oculus Rift marked a turning point in the development of VR technology. Following Oculus Rift, other manufacturers like HTC Vive and PlayStation VR entered the market. In 2015, HTC began producing its HMD set, hinting at further IVR technology development. Google introduced its AR glasses, Google Glass (2013), enabling the display of real-time information over the real world. Pokemon Go (2016) was a game that popularized AR among the wider audience by combining the real world with digital characters. This historical overview illustrates how iVR has evolved over time, from early influences to today's technological innovations and popularization among the masses. All of this represents just a part of the story of iVR's journey through time, bringing us new dimensions of digital experience that are increasingly becoming part of our daily lives.

Review of Relevant Literature

The book „Virtual Reality in Clinical Psychology: A Systematic Review of Recent Evidence" by Garcia-Palacios et al[1]. from 2018 provides a systematic review of recent research on the application of virtual reality (VR) in clinical psychology. The authors analyze a wide range of studies that deal with the use of VR in clinical psychology, focusing on various forms of treatment, assessing their effectiveness, and their contribution to the therapeutic process. The book explores how VR technology is used to treat different mental conditions such as anxiety, phobias, depression, PTSD, and other disorders, providing an overview of different therapeutic techniques and innovations using VR. Through a systematic review of literature, the authors highlight the advantages of using VR technology in therapy, such as greater treatment personalization, simulation of real-life situations, exposure control, and improvement in therapeutic outcomes. Additionally, the book addresses the challenges in applying VR in clinical psychology, including technical aspects, ethical issues, and the ongoing need for research. This book offers an overview of recent studies, emphasizing how VR technology has the potential to be beneficial in clinical psychology while also pointing out the need for further research and technological advancement for a better understanding of its therapeutic capabilities and limitations [1, 2].

The book „Virtual Reality Technology" by Grigorea C. Burdea and Philippe Coiffet from 2016 is a comprehensive review of virtual reality technology covering a wide range of topics relevant to this field[2]. Starting with a review of the history of VR, from early pioneering works in the 1950s and 1960s to the latest trends and technologies, the book covers the history of VR, basic principles, different applications, and research in this area. It explains the fundamental principles of VR, including graphical representation, sound, haptic feedback, and interaction. Furthermore, it describes various input and output components used in VR systems, such as head-mounted displays (HMDs), controllers, haptic devices, and spatial sensors. The book discusses various computer architectures that can support VR, including centralized and decentralized architectures. It introduces programming for VR, including programming languages and libraries used for developing VR applications. It further explores human factors relevant to VR, such as perception, cognitive processes, and physical response. Additionally, it provides an overview of traditional VR applications, including gaming, education, entertainment, medicine, and engineering. The authors discuss emerging VR applications such as augmented reality (AR), virtual augmented reality (VAR), and holographic reality (HR). The book is rich in illustrations and examples, making it a useful resource for students, researchers, and professionals interested in virtual reality.

The book „Virtual Reality for Mental Health: A Review" by Botella, C et al. from 2012 [3] provides a comprehensive review of the use of virtual reality (VR) in the context of mental health. Focusing on the application of VR technology in therapy and support for individuals dealing with mental disorders, this book explores various forms of clinical applications of VR. The authors analyze how VR can be an effective tool for treating different mental problems such as anxiety, phobias, PTSD, depression, and other types of disorders. They re-

[1] Garcia-Palacios A., Botella C., Botella L. Virtual reality in clinical psychology: A systematic review of recent evidence. *Clinical Psychology Review.* 2018;64:17-34.

[2] Burdea G.C., Coiffet P. Virtual Reality Technology. 3rd Ed. Wiley-IEEE Press; 2024. 736 p.

view various therapeutic techniques using VR, such as VR exposure therapy, cognitive-behavioral therapy based on VR, virtual reality as a means of relaxation and stress reduction, and other therapeutic innovations. The book provides insights into previous research supporting the use of VR technology in the therapy of mental disorders, highlighting the benefits it offers, such as exposure control to stimuli, improved therapeutic accessibility, and support for personalized therapy. It also addresses the need for further research, identifying shortcomings and challenges faced by this field, including technical, ethical, and methodological obstacles. The book relies on previous research and case studies to emphasize how VR technology can be useful and significant in improving mental health, laying the foundation for future therapeutic innovations and research in this field.

„Virtual Reality Exposure Therapy for Anxiety Disorders: Small Samples and No Benchmarks" [4] – This study examines the effectiveness of exposure therapy using VR for anxiety disorders, emphasizing the need for further research and method standardization.

The study by Veling and colleagues [5] investigates the potential of virtual reality in studying perceptual and affective processes in individuals with schizophrenia. The focus is on using VR technology to simulate various scenarios and environments to understand the reactions of individuals with this disorder. The authors explore how VR can replicate situations relevant to individuals with schizophrenia, such as feelings of paranoia, perceptual experiences, or social interactions. By utilizing VR, researchers can control and adapt environments to test different aspects of perception, emotions, and behavior within this population. This research suggests that VR could be a valuable tool for better understanding the inner world of individuals with schizophrenia. It enables researchers to simulate realistic scenarios and observe how individuals with this disorder experience and respond to specific situations. Such an approach could provide a deeper insight into the perceptual and affective processes in schizophrenia, potentially impacting the development of therapies and interventions aimed at improving the quality of life for these individuals.

Furthermore, the study „Virtual reality exposure therapy in anxiety disorders: a systematic review of process-and-outcome studies" [6] analyzes the processes and outcomes of exposure therapy using VR for various anxiety disorders, providing a detailed overview of their effectiveness. The primary objective of the meta-analysis is to compare the effectiveness of VRET, used within behavioral or cognitive-behavioral approaches, with conventional evidence-based therapies for anxiety disorders.

Additionally, the paper „Virtual Reality and Anxiety Disorders: Current Status and Future Directions" [7] also provides significant insights into the use of VR in the context of rehabilitation and anxiety treatment. This article explores the application of virtual reality technology in treating anxiety and other mental disorders. The authors analyze the use of VR technology as a therapeutic tool in mental health, highlighting various studies and research that applied VR in treating anxiety, post-traumatic stress disorder (PTSD), phobias, depression, and other disorders. The paper examines how VR offers the possibility of simulating real or imaginary situations used for therapeutic purposes. Focusing on different therapeutic techniques, the authors emphasize the significance of VR technology in creating a safe environment for exposing patients to situations that trigger anxiety or fear. Additionally, the article explores how VR technology can provide personalized therapeutic approaches tailored to individual patient needs. The authors also discuss the challenges and possibilities in using VR technology in therapy, highlighting the potential of this technology to enhance therapeutic outcomes. Ultimately, the article suggests the need for further research and standardization of protocols in using VR technology in the treatment of mental disorders.

This literature provides diverse perspectives on the effects of IVR on mental and physical health, encompassing various disorders, therapeutic approaches, and applications of IVR in medicine and rehabilitation.

„The Ethics of Virtual Reality Technology: Social Hazards and Public Policy Recommendations" by Spiegel (2018) explores the ethical challenges associated with virtual reality (VR) technology. It focuses on potential social hazards brought about by VR and provides recommendations for public policies related to this technological advancement. The author analyzes various ethical dilemmas in the use of VR, emphasizing the importance of privacy protection, data integrity, and responsibility in using this technology. The paper also offers recommendations to mitigate risks and create guidelines for the responsible use of VR, aiming to ensure that this technology brings societal benefits while minimizing potential harmful impacts.

Types of immersive virtual reality

Immersive Virtual Reality (iVR) encompasses a broad spectrum of experiences that vary in the degree of immersion, from basic to full virtual experiences. This categorization by degree of immersion defines how users perceive and interact with the virtual world. The following is a breakdown of iVR based on the degree of immersion:

1. Low immersion encompasses the most basic forms of iVR that are the least immersive. This includes 2D and 3D content displayed on screens, such as computers and mobile devices. At this level, users remain aware of their actual surroundings while consuming digital content. Low immersion also includes simple simulations like video games, which, although providing a certain level of interaction, do not offer complete immersion in the virtual world.
2. Moderate immersion in iVR includes Augmented Reality (AR) and moves towards greater immersion. AR combines digital content with the real world, providing users with an enhanced experience. Through AR applications on smartphones or through special glasses/devices, users can see digital content in their real environment. While users still perceive the real world, AR technology allows them to interact with digital objects or information within that environment.
3. High immersion is characterized by a more complete immersion into the virtual world. This level includes Virtual Reality (VR), where users are fully transported into the digital world using special devices like VR headsets or earphones. Here, users experience complete isolation from the real world, surrounded exclusively by digital content that responds to their movements and interactions.
4. Extreme immersion represents the highest degree and may involve more complex forms of iVR, such as haptic interactions, multi-sensory simulations, and a complete sense of presence in the virtual world. The aim here is to create experiences that integrate multiple user senses, including touch, smell, sound, and visual stimulation, to achieve the most realistic sense of presence.

This categorization by degree of immersion enables an understanding of the different levels of iVR and how they differ in their characteristics and impact on user experience. Each level offers unique opportunities and challenges in application, driving the continuous development of this technology.

Key Elements of Virtual Reality

Virtual reality is a technology that creates a simulated environment, allowing users to interactively experience and explore digital worlds. Virtual reality comprises several key elements that together create an immersive experience:

1. Visual Elements: The central component of VR is the visual representation of the virtual world. This includes high-quality graphics, textures, lighting, and rendering to create a sense of reality. Real-time rendering demands high computational processing to generate and update images instantly. The ability to create realistic images is crucial for a sense of presence in the virtual space. This component involves creating and displaying visual elements in the virtual space, constituting the environment and including the creation of 3D models, textures, lighting, and animation. The Head-Mounted Display (HMD) worn on the head serves as the interface between the user and VR content, providing a visual experience by immersing the user into the virtual environment.
2. Audio Elements: Sound plays a significant role in creating an immersive environment. 3D audio technology dynamically adjusts sound based on the user's movement within the virtual space, adding an extra layer of authenticity by allowing users to hear environment sounds that change with their movements.
3. Interactivity: Interactivity enables users to manipulate and interact with the virtual world. Controllers, as well as motion tracking devices, allow users to manipulate objects, interact with the environment, and manage their experience. These can be handheld controllers, specialized finger devices, or even gestures and voice commands.
4. Haptics: The haptic aspects of VR involve devices that provide physical feedback to users, such as vibrations, pressure, or even simulating touch. These devices add a deeper dimension to the experience, enabling users to feel physical contact with virtual objects.
5. Sensors and Tracking: Motion tracking sensors are crucial for monitoring user movements and positions in the real world. This allows movements to be translated into the virtual space, creating a sense of connection between the user and the digital world. Sensors can be integrated into HMDs, use cameras, or other technology like sensors on hands or feet.
6. Computational Power: Delivering a quality VR experience requires significant computational power. Software and hardware optimization enable rapid data processing, critical for creating and maintaining high-level graphics and performance. This component includes hardware and software resources needed for creating and processing VR content, which may involve powerful computing systems, high-performance GPUs, and software platforms for VR application development.

The combination of these elements provides an immersive experience in virtual reality. Technological advancements in these areas enable increasingly realistic VR experiences, opening new application possibilities in education, the medical industry, entertainment, and business. Continuous development and improvement of technology expand the boundaries of virtual reality possibilities, laying the groundwork for future innovations and applications.

Discussion of Results

Immersive virtual reality (iVR) represents an advanced technological concept that has the potential to revolutionize how we experience the world. Unlike traditional media that passively expose us to information, VR places us at the heart of simulation, enabling us to move freely, interact with objects, and adapt to the virtual environment intuitively. This ability to bridge the gap between the real and virtual worlds creates unique opportunities for creativity, learning, entertainment, and even therapy.

One of the most significant advantages of immersive VR is its ability to create fully immersive worlds, which is truly fascinating. With the use of VR headsets, creating entirely new worlds becomes an immediate reality. Imagine being instantly transported to the top of Mount Everest or exploring the ancient Roman Colosseum—all from the comfort of your own home. This potential for complete immersion allows for a deep emotional connection with the virtual environment. The sense of actual presence in that world, although virtual, can evoke powerful emotional reactions and open doors to new experiences and ways of interacting with the digital world.

Immersive VR also holds great educational potential. It's possible to learn about history, geography, science, and art through interaction with virtual reconstructions, simulations, and experiments. For instance, a student can study human anatomy by exploring a virtual body or learn about biology by observing a virtual ecosystem in real-time. This interactive learning can be significantly engaging and more effective than traditional teaching methods.

Entertainment is another area undergoing significant transformation with immersive VR. Video games have already begun integrating VR technology, providing players with an unprecedented level of immersion and interactivity. In the future, VR could be used to create new types of entertainment experiences, such as virtual concerts, sports events, and escape rooms.

Immersive VR also has the potential for therapeutic purposes [8]. For example, it can be used to treat phobias, post-traumatic stress disorder (PTSD), and other mental health conditions. VR therapy may be more effective than traditional methods because it allows patients to confront their fears in a safe and controlled environment.

However, immersive VR is not without its challenges. One of the main concerns is the possibility of adverse effects such as nausea, headaches, and dizziness. There is also a risk of addiction and social isolation, as individuals may become so engrossed in their virtual lives that they neglect their responsibilities in the real world.

Despite the challenges, immersive VR represents an exciting new technology with tremendous potential. As the technology develops, we can expect it to become more widely available and accessible, impacting all aspects of our lives. Immersive VR has the power to change the way we learn, play, work, and communicate. Whether this potential is leveraged in a positive or negative way depends on us.

The Impact of iVR on Humans Immersive

Virtual Reality (iVR) is becoming increasingly prevalent in our daily lives, reshaping the way we perceive reality. While IVR technology

brings innovations and possibilities, researchers are increasingly studying its impact on users' mental and physical health.

One of the key aspects is mental health. The use of iVR can significantly impact users' psyche. When used for therapy, such as exposure techniques in controlled environments, iVR can aid in treating phobias, PTSD, and anxiety. However, concerns exist that excessive iVR usage might cause depersonalization or dissociation, leading to a loss of a sense of reality and connection with the real world.

Furthermore, iVR can affect reality perception [5]. As users enter the immersive world, the boundary between the virtual and the real can become blurred. This could lead to various effects on the user's perception, such as the existence of false memories or changes in the way specific events are remembered.

Regarding physical health, iVR usage can also lead to some adverse effects. Prolonged usage might cause eye strain, dizziness, nausea, or other issues like joint and muscle pain due to inadequate body positioning during use.

Despite potential risks, iVR also offers many benefits. It is used in rehabilitation [7], education, medicine, and various other fields. It allows the simulation of real situations that would otherwise be dangerous or costly for training, reducing risks for users.

Considering all these factors, researching the impact of iVR on mental and physical health is crucial [4]. Deeper understanding is necessary to identify potential risks and use this technology in a way that maximizes benefits while minimizing risks for users. A comprehensive analysis of iVR's impact on people, applying ethical guidelines, represents a crucial step in understanding and establishing a balance between innovation and user health.

Ethical Dilemmas

Immersive Virtual Reality (iVR) brings along a set of ethical dilemmas that require careful consideration and the establishment of clear guidelines and legal regulations to protect users. Here are some key issues and recommended guidelines:

Data Privacy: iVR systems often collect user data, including biometric information and emotional reactions. An ethical approach involves clear privacy policies, data collection notices, and user consent. Regulations should mandate transparency regarding the data collected and used by iVR.

The widespread use of iVR leads to the collection of sensitive user data. The article „The ethics of virtual and augmented reality: building worlds" explores privacy concerns in iVR, emphasizing the need for clear rules on data collection and usage to protect user privacy[3].

User Safety: iVR can evoke emotional or physical reactions in users. Establishing safety standards, such as certifications for iVR applications, could ensure that these applications are secure and minimize potential risks to users.

Ethics in Design: iVR design must be responsible. Designers should be aware of potential impacts on users and develop systems that do not lead to exploitation or undesired effects, especially on mental health.

Data Misuse [9, 10]: iVR data can be misused for manipulation, tracking, or discrimination. Ethical guidelines should prohibit the misuse of this data, protecting users from unauthorized use or sale of their data.

Education and Information: iVR users should be educated about its potential risks and benefits. Ethical guidelines should require iVR providers to train users on proper usage, risks, and their rights.

Legal Regulations: Laws should keep pace with iVR developments and be flexible enough to adapt regulations to new technological changes. Also, companies developing iVR technologies should have a responsibility to comply with legal frameworks [11-14].

Regulating iVR requires collaboration among ethics, technology, legislative experts, and the industry. Developing clear guidelines and legal regulations is a crucial step in protecting iVR users, ensuring data integrity, and maintaining accountability in using this technology.

Availability of Immersive Virtual Reality

The availability of Immersive Virtual Reality (iVR) faces several obstacles that limit its wider adoption and usage. High equipment costs are one of the main factors. Quality VR headsets, sensors, and computer systems remain relatively expensive, often placing this technology beyond the financial reach of average users. Although equipment prices have been decreasing over the years, they still remain relatively high.

Another obstacle is associated with infrastructure. Using iVR requires powerful computers and a fast, reliable internet connection. In many parts of the world, especially in rural or less developed areas, the lack of necessary technological infrastructure often limits the potential utilization of iVR.

Technical barriers pose an additional challenge. Using iVR requires a certain level of technical knowledge and skills. Lack of familiarity with the technology or insecurity in handling this equipment can be barriers for users.

Solutions to these challenges include reducing production costs and improving equipment efficiency. Continuous technological development, along with investment in research and innovation, can lead to the creation of more affordable and cheaper VR devices. Educating users and providing support in using the technology is also essential as it can help in reducing technical barriers.

Additionally, investing in improving infrastructure, such as enhancing internet networks and computer capacities, is crucial for enabling a better iVR experience. Also, establishing regulations and standards that support the development of more accessible iVR technology would encourage its broader adoption.

All these changes and innovations can help in expanding the availability of iVR, allowing a larger number of people to reap the benefits of this technology in various aspects of life [15, 16].

Applications of iVR

Immersive Virtual Reality (iVR) represents a revolutionary technology with broad applications across various spheres of society and industry. Here is a more detailed insight into some key areas of iVR application:

1. Entertainment and Gaming: iVR has transformed the entertainment and gaming industry. Users can fully immerse themselves in virtual worlds, providing them with intense experiences and interactivity. The development of VR games has enabled the creation of realistic experiences surpassing traditional games.

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2. Education and Training: Educational institutions increasingly use iVR to enhance teaching and education in specific conditions (training for paratroopers, astronauts, nuclear plant maintenance specialists, etc.). Simulations enable students to experience complex concepts in an interactive way, facilitating their understanding of difficult subjects. It is used for training in complex skills such as surgery, driving, or military training.
3. Medicine and Therapy: The healthcare field uses iVR for therapy of medical disorders like phobias, anxiety, and PTSD. Through controlled environments, patients are exposed to their fears in a safe space, allowing them to gradually overcome their issues. It‘s applied in physical rehabilitation after injuries, aiding patients in restoring functions.
4. Engineering and Design: Architects, engineers, and designers use iVR to test prototypes before physical construction (project simulations). This saves time and resources, enabling better project planning. It helps designers to create, test, and optimize products before bringing them into physical form (prototype creation).
5. Tourism and Cultural Heritage: iVR allows users to virtually visit destinations worldwide and historical monuments from the comfort of their homes (virtual travel). This contributes to spreading cultural knowledge and facilitates travel planning. Museums use iVR to provide visitors with a more interactive experience.
6. Business Applications: Companies use iVR to present products and services to potential clients (product presentations). It facilitates team collaboration among people worldwide.
7. Research and Science: Researchers use iVR to study dangerous environments or simulate inaccessible places, providing a deeper understanding of phenomena that cannot be easily studied in the real world. It allows researchers access to otherwise inaccessible places, such as space or oceans (simulation of hazardous environments). It‘s used to study human behavior in controlled conditions.
8. Networking and Social Interaction: iVR provides the opportunity for social interaction through virtual spaces, allowing people to connect worldwide without physical presence (remote meetings).

Key challenges and further development of iVR technology focus on reducing costs, improving system performance, and increasing accessibility to make this technology more widely accepted and available to a broader population [17-21].

Conclusions

iVR, or Immersive Virtual Reality, represents a technology that allows users to fully immerse themselves in a three-dimensional environment through special electronic equipment. This experience surpasses mere screen viewing, enabling users to actively interact with a digital world that feels real and physically present.

This technology enables users not only to observe the digital world but also to „fit into“ it. This means they not only see but also interact with objects and the environment within the virtual world, creating a sense of these objects being part of the real world.

Speaking of Virtual Reality (VR), it refers to the creation of an artificial environment or scene through software. Through VR, users can „dive into“ that scene and experience it as real, often forgetting they are in the physical world. Immersiveness refers to the technology or image‘s ability to engage one or more of the user‘s senses in a way that induces deep involvement and may even alter mental states.

Cyberspace, a term introduced by William Gibson, describes the connection of technical systems with human beings, the process of transforming the real world into a virtual technological world. It creates a new space, a new environment that transcends the traditional physical world and opens up new possibilities for communication and interaction.

iVR provides users with the ability not only to experience digital worlds intensely but also to manipulate objects within those worlds. It enables the exploration of unknown territories of imagination, paving the way for new forms of interaction, learning, and creation, offering opportunities for entirely new experiences beyond traditional screen viewing or consuming media content.

This technology requires complex computer systems that create effects of 3D environments with a defined presence in space concerning the user. Therefore, through iVR, users not only immerse themselves in the digital world but also have a sense of real presence and interaction with things within that world.

Immersive Virtual Reality (iVR) plays a significant role in military operations, enhancing military training, operation planning, and technology development. Through simulations, the military sectors use iVR to provide soldiers with experience without real risks, preparing them for a wide range of scenarios in combat situations.

The application of iVR for military purposes brings numerous advantages, including more realistic training, more efficient operation planning and execution, reduced risks to soldiers‘ lives, and the development of innovative technologies. However, high costs, technology maintenance, and the need for constant improvement pose challenges. Overall, iVR has a significant impact on the modernization of the military sector and the enhancement of its capabilities.

Future Work

Virtual Reality (VR) represents a technology that comes with a set of advantages and disadvantages, each crucial for understanding its usage and potential. Studies from UCLA highlight changes in the function of the hypothalamus, the part of the brain responsible for memory and mental mapping, when using VR devices. The absence of smell, sound, and memory affects its function, potentially limiting mental mapping. Additionally, the impact on visual perception can cause difficulties in coordinating between the eye and hand.

Extended use of VR can lead to discomfort such as dizziness and nausea. Some researchers have also emphasized the possibility of developing psychological addiction, especially considering the widespread use of VR technology in gaming.

However, VR technology also holds a range of advantages. It allows the creation of realistic simulations useful for various purposes. Its applications in fields like medicine, architecture, military industries, and tourism illustrate its immense potential. For instance, NASA uses VR for controlling robots in explorations of inaccessible locations, while in the tourism industry, it‘s used for virtual tours, aiding users in choosing destinations.

This technology also finds application in education, facilitating learning and training in various domains. Methods like virtual driving training represent just one example of VR technology application in education [22, 23].

While VR presents certain challenges and drawbacks, its advantages across different spheres of life and science showcase its significant potential for the future.

Potential directions for further research:

1. Deeper investigation into the impact of iVR on mental health [24, 25], perception of reality, depersonalization, and other effects, even on users' physical health, to understand potential risks and benefits.
2. Analysis of ethical dilemmas associated with iVR and the development of ethical guidelines and legal regulations to protect privacy, data integrity, and ensure accountability in iVR usage.
3. Development of technological innovations that would reduce costs, enhance technical infrastructure, and enable accessibility of iVR to a wider user base.
4. Development of educational programs and the application of iVR in education, medicine, arts, and other spheres of life to explore its practical applications and benefits.

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