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ORIGINAL

Optimized design of digital ledger posting based on virtual reality technology

Diseño optimizado de contabilización en libros de contabilidad digitales basado en tecnología de realidad virtual

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ABSTRACT

The study examined optimized design of digital ledger posting based on virtual reality technology. The convention of Virtual Reality (VR) and Distributed Ledger Technology (DLT) is a revolutionary change in the design and interaction of digital systems. The study finds that there are several design principles and technological considerations that were critical to the implementation of VR-enhanced digital ledger systems to succeed by a thorough examination of the existing literature and case studies. This research design is a qualitative study and will involve an exploratory approach to research the topic of Virtual Reality (VR) implementation with digital ledger posting systems. The study mainly includes a literature review and case study analysis of the existing literature and case studies in order to draw best practice and practical information. Case studies are also used as one of the main methodological instruments to provide the real-life examples of VR in financial, accounting, and the sphere of supply chains. The research is aimed at gaining insight into the way VR would maximize digital ledger posting, and not the quantification of predetermined variables. It was revealed in the study that VR provides users with many chances to perceive multidimensional datasets in a way that is not possible in a traditional 2D interface. The study concluded that the ongoing development of the digital economy, these systems will be able to increase the levels of transparency, minimize errors, and promote more efficient and cooperative and resilient organizational processes.

Keywords: Optimized Design; Distributed Ledger Technology; Virtual Reality; Technology; Blockchain.

RESUMEN

El estudio examinó el diseño optimizado de la contabilización en libros de contabilidad digitales basado en la tecnología de realidad virtual. La combinación de la realidad virtual (RV) y la tecnología de libros de contabilidad distribuidos (DLT) supone un cambio revolucionario en el diseño y la interacción de los sistemas digitales. El estudio concluye que existen varios principios de diseño y consideraciones tecnológicas que fueron fundamentales para el éxito de la implementación de sistemas de libros de contabilidad digitales mejorados con RV, tras un examen exhaustivo de la bibliografía y los estudios de casos existentes. El diseño de esta investigación es un estudio cualitativo y adoptará un enfoque exploratorio para investigar el tema de la implementación de la realidad virtual (RV) en los sistemas de contabilización de libros de contabilidad digitales. El estudio incluye principalmente una revisión de la bibliografía y un análisis de los estudios de casos existentes con el fin de extraer las mejores prácticas y la información más útil. Los estudios de casos también se utilizan como uno de los principales instrumentos metodológicos para proporcionar ejemplos reales de la RV en el ámbito financiero, contable y de las cadenas de suministro. La investigación tiene como objetivo obtener información sobre la forma en que la RV maximizaría la contabilización en libros de contabilidad digitales, y no la cuantificación de variables predeterminadas. El estudio reveló que la RV ofrece a los usuarios muchas oportunidades de percibir conjuntos de datos multidimensionales de una manera que no es posible en una interfaz 2D tradicional. El estudio concluyó que, con el desarrollo continuo de la economía digital, estos sistemas podrán aumentar los niveles de transparencia, minimizar los errores y promover procesos organizativos más eficientes, cooperativos y resilientes.

Palabras clave: Diseño Optimizado; Tecnología De Contabilidad Distribuida; Realidad Virtual; Tecnología; Cadena de Bloques.

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INTRODUCTION

The convention of Virtual Reality (VR) and Distributed Ledger Technology (DLT) is a revolutionary change in the design and interaction of digital systems.[1] VR, as an immersive technology, can simulate environments; it has been applied in many fields, including education, health care, entertainment, etc. In blockchain, a decentralized and secure way to record the transactions and handle the data is provided by DLT.[2,3] The combination of these technologies would be used to improve the interaction with users, visualization of data and efficiency of the work in digital systems. Thus, with regard to digital ledger systems, traditional interfaces can have issues concerning user interaction and understanding of data. As an example, abstract representations and complex data structures may be an obstacle on the way of users communicating, as well as making sense of the information shown. This problem is especially relevant to such spheres as finance and accounting, where the interpretation of accurate data is essential.[4]

VR use in those sphere can offer a solution, as it allows more easily understanding the complex data in the form of immersive and interactive environment. The three-dimensional spaces of visualizing the data provide the user with an insight that cannot be easily observed in the traditional two-dimensional interfaces. Besides, VR provides real-time teamwork and simulation training and scenario training, improving the process of decision-making.[5]

Nonetheless, VR being integrated with the use of DLT comes with new challenges especially in terms of system design and development of user interface. To make sure that the VR interfaces used are easy and user-intuitive, one should take into account the principles of design and factors of user experience. Moreover, the technical details of the integration of VR with the existing systems of the DLT requires new methods of developing software and designing the system.[6]

The paper will discuss the optimized design of the digital ledger posting systems with the help of VR technology, to improve the user experience and operational efficiency. The paper finds that there are several design principles and technological considerations that were critical to the implementation of VR-enhanced digital ledger systems to succeed by a thorough examination of the existing literature and case studies.

Finally, the adoption of VR and DLT has a great potential to transform the digital systems by offering more interactive and efficient user interface. By finding solutions to issues that come with this integration, organizations are able to come up with a system that is not only relevant to the current problems of technology but also responsive to upcoming developments and changes.

The combination of Virtual Reality (VR) and Distributed Ledger Technology (DLT), is transforming the world of digital systems and providing new solutions to the old difficulties in the visualization of data, interaction with the user, and transparency of the system.[2,7] This convergence is especially relevant to the industry areas like the financial sector, supply chain management, and healthcare area where multifaceted data sets and secure transactions with transparency are common.

Digital Systems Virtual Reality

Virtual Reality technology is a computer-generated simulation, or real-world simulating environment. VR leads to the increased interaction between the users in digital systems as it enables the user to interact with information in three-dimensional and natural ways. The VR headsets and motion tracking devices are used to create this immersive experience so that the users are able to manipulate and explore data sets in the form of three-dimensional objects. VR usage in digital interfaces has been demonstrated as essential in enhancing the comprehension and choice-making of the user through more interactive and involving interface.[8]

Distributed Ledger Technology (DLT)

Distributed Ledger Technology is a type of decentralized database system in which data is stored in various places and all copies of the data are synchronized so that all are kept safe. In contrast to the conventional centralized databases, DLT is a peer-to-peer network, with participants having a copy of the ledger, and the updates are made by consensus mechanisms.[9] The structure provides an improvement in data integrity and transparency, which makes it especially applicable to the applications that demand solid and unrestricted records, including financial operations and supply chains.[9]

Problems with Traditional Digital Ledger Systems

The conventional digital ledger systems are usually based on two-dimensional interfaces, which may prove to be restrictive with more complex data structures. It might be difficult to process and communicate with significant amounts of data that are displayed in tabular form. Moreover, the inability to identify patterns, anomalies, or relationships in the data by using immersive visualization tools may hamper the ability of the users to work with the data efficiently and the process of making decisions might be affected by erroneous decisions.[10]

The VR use to improve Digital Ledger Systems

The VR implementation into digital ledger systems can solve those issues by offering users the environment into which they can engage with the data on a 3D scale.[11] The VR will also be useful in displaying complex data sets as three dimensional objects and provide a user with an opportunity to operate and navigate the data in different positions. The interactive nature of this kind of design makes the user more engaged and understanding which in turn makes the analysis and decision making more effective. Additionally, VR has the potential to facilitate real-time work with a user, allowing various stakeholders to communicate with the ledger at the same time and enhance the process of coordination and efficiency, including auditing and reporting.[12]

The integration of VR with DLT provides an opportunity to streamline the digital ledger systems. Using the virtual reality features and a secure and decentralized system of the DLT, companies can create systems that, in addition to offering an improved user experience, enhance data visibility and integrity. This integration is a good development that will lead to better management

of complex data that is more efficient and effective as a result of integration in the design and functionality of the digital systems.

METHOD

This research design is a qualitative study and will involve an exploratory approach to research the topic of Virtual Reality (VR) implementation with digital ledger posting systems. Qualitative research is well-suited in the case of emerging technologies and complex interaction of systems, since it can be used to study such phenomena in depth, which are not readily measurable.[13] The qualitative method, in this case, can be used to explore the principles of design, the user experience, and the technological requirements related to the VR-based digital ledger systems.

The study mainly includes a literature review and case study analysis of the existing literature and case studies in order to draw best practice and practical information. Literature review provides the opportunity to synthesize previous research results and theoretical constructs, which guarantees that the study is based on the existing knowledge and introduces gaps that can be filled with the new study.[14] The research based on peer-reviewed publications, conferences, and industry reports obtains a great amount of insights into the existing status of VR integration in digital ledger systems and how it may influence the efficiency of operations and user experience.

Case studies are also used as one of the main methodological instruments to provide the real-life examples of VR in financial, accounting, and the sphere of supply chains. Case study research allows delving into complex systems in a natural environment, which will allow presented evidence to be practical on how VR-supported digital ledgers are applied and used.[15] This method is especially useful to examine new technologies whose empirical data might not be available, and whose subtleties of practice are of paramount importance in drawing actionable conclusions.

The qualitative methodology is also chosen because of the exploratory quality of the research question. The research is aimed at gaining insight into the way VR would maximize digital ledger posting, and not the quantification of predetermined variables. This is in accordance with the opinion of Maxwell,[16] that qualitative approaches are best suited to produce rich, situational insights into processes, interactions, and design principles, which are the primary topic in technology adoption and interface optimization.

Also, the methodology underpins triangulation that enhances validity of the results, as it is based on the combination of numerous sources of information such as literature knowledge, professional views and documented case studies. Triangulation can minimize the biases that are linked to the use of single-source data and increase the validity of the conclusions made in the study.[17]

Consequently, the qualitative, exploratory approach, which is based on the literature review and case study analysis, should be chosen to study the optimized design of VR-based digital ledger systems. In this way, the theoretical and practical aspects can be considered in their whole, and the investigation will include practical recommendations on how the future design and implementation may be conducted.

DEVELOPMENT

VR Bedigger Digital Ledger Systems Design Principles

The successful development of Virtual Reality (VR) integration into digital ledgers system presupposes a balanced approach to several design principles and the ability to consider such factors as usability, data integrity, and technological feasibility. They are based on the human-computer interaction (HCI) theory, the best practices of designing a VR interface, and the architecture of blockchain systems.[18,19]

The fourth article is titled Immersive Data Visualization

Immersive visualization enables one to engage with ledger data in a 3D space, and move abstract numerical values into an object-centered space. Using VR, users may navigate financial transactions, engage with single ledger lines and see trends or anomalies which would otherwise be hard to identify in a traditional two-dimensional table.[8]

As an example, the flow of transactions could be a node and an edge in a 3D network, with the size or colour of the node reflecting the size or nature of the transaction. VR interactive dashboards enable the ability to filter and drill into certain accounts, making data easier to navigate and lessening cognitive load.[20]

Intuitive User Interfaces

The intuitive interfaces are very important in making sure that VR-based ledger systems are user-friendly to both technical and non-technical users. The ability to manipulate objects and gesture-based controls in the VR environment, as well as spatial layouts, ease the learning curve and increase engagement.[18]

Ledgers can be navigated like virtual rooms or tables with each table representing a particular account or category and transactions are displayed as floating objects. These interfaces are designed on the basis of the principles of HCI, such as feedback, affordance, and consistency modified to fit the immersive VR environment.[21]

Real-Time Collaboration

VR environments support real-time work of various stakeholders. Ledger entries can be jointly analyzed and decision-making will be supported by allowing simultaneous viewing and manipulation of data in a shared virtual space by auditors, accountants, and managers. The collaborative capability is a way to overcome the drawbacks of previous digital ledger systems, where cooperation is usually not active and can only be achieved via screen-sharing tools.[22]

Security and Privacy

The implementation of VR that is connected with ledger should take security into account. The sensitive financial data needs to be secured in the VR space with the help of access control, encryption and multi-factor authentication. Also, accountability and the absence of authorized manipulation may be ensured by the use of activity logs and verification based on blockgender.[23]

Ledger Design Diagram

The architecture and workflow of a VR-based ledger system can be communicated with the help of its visual representation. Figure 1 represents a conceptual design of a VR digital ledger system (figure 1).

Below is a descriptive layout of the virtual conceptual design

- Input Layer: the transactions are captured in various sources (banks, internal systems or IoT devices).
- Ledger Layer: this is a distributed cryptographically-validated ledger (blockchain) where transactions are recorded.
- VR Interface Layer: ledger is displayed in 3D, the nodes in the ledger are the accounts and transactions so that the ledger could be interactively manipulated and analyzed.
- Collaboration Layer: the collaboration experience is in real-time, and users share views and can use gestures.
- Security Layer: there is the use of encryption, access control and audit trails which guarantee the data integrity and privacy.

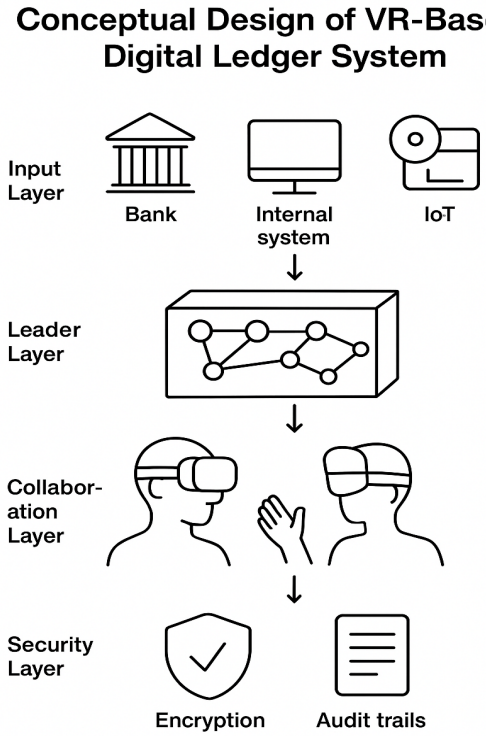


Figure 1. Design of VR-based on digital ledger system as Adopted

This structure will make the system modular, scalable, and adaptable as well as create a highly interactive and immersive user experience.[24,25]

In the design, there are principles and these principles make the digital ledger systems that are created with VR not only technologically feasible but also easy to use and with security incretions. Through immersive visualization, user-friendly interfaces, teamwork features, and powerful security features, organizations will be able to streamline the ledger posting operations, minimize errors and improve the efficiency of their decision-making.

Technological Considerations

The installation of digital ledger systems based on Virtual Reality (VR) depends on a thorough thought of technological infrastructure. This part describes the hard requirements of hardware, software development and integration with the existing systems.

Hardware Requirements

VR-based digital ledger system implementation is also effective only with the help of specific hardware that promotes immersion and accurate interaction. The main elements are high resolution VR headsets, motion tracking systems, haptic feedback systems and high-performance computing systems that can run real time 3D graphics. The choice of suitable hardware is also very important because inappropriate equipment may lead to latency, motion sickness, or poor user experience, which may negate the implementation

of the system.[26,27] Moreover, network infrastructure needs to be able to support low-latency communication especially when using distributed ledger to maintain consistency of data among participants.

Software Development

The creation of the VR-based digital ledger systems software involves both interdisciplinary skills in blockchain technology, VR app development, and user experience (UX) design. Unity and Unreal Engine frameworks can be used to create very interactive and immersive VR experiences and integrate with blockchain networks using software development kits (SDKs) and application programming interfaces (APIs).[28] Some of the important factors to consider are the design of easy-to-use interfaces that would enable the user to interact with ledger data without any issues, use of secure transaction systems and scalability to support multiple users at a given time. Also, the software architecture should be security-driven because VR interfaces become a new avenue with all types of cyber threats.

Interaction with the Existing Systems

To integrate VR-based interfaces with the existing digital ledger systems, it is necessary to guarantee that they should be compatible with the existing blockchain protocols and data structures. Intermediate software or dedicated APIs can frequently be required to connect VR applications with already existing ledger networks in order to synchronize transactional information and ensure ledger integrity.[29] Regulatory compliance, data privacy and the interoperability of various blockchain platforms should also be considered during this process of integration. As part of integrating properly, the end users are able to take advantage of the immersive VR capabilities without affecting the operational stability or reliability of the underlying ledger system. Figure 2 picture the technological considerations:

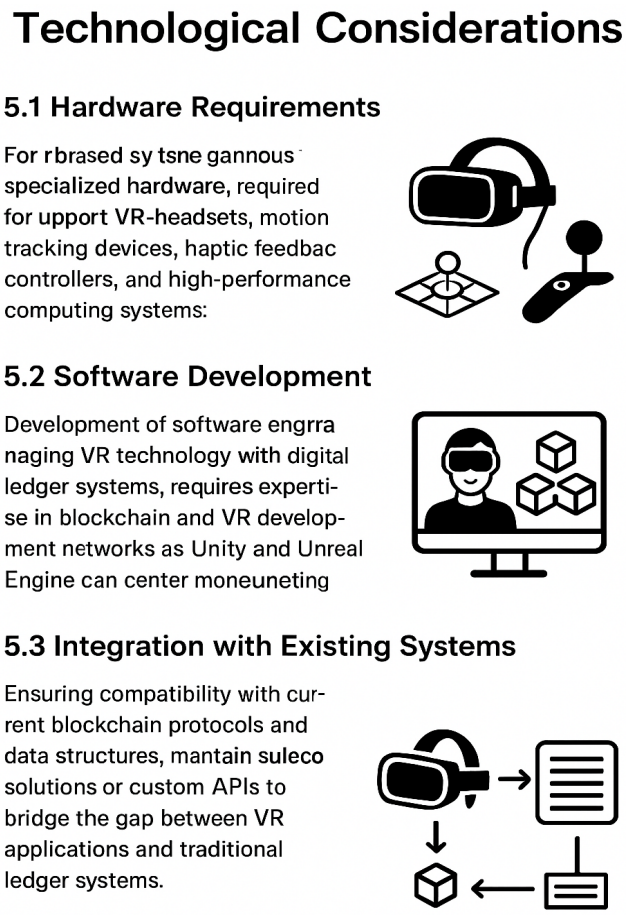


Figure 2. Technological considerations as adopted

CASE STUDIES

Financial Auditing

Virtual Reality (VR) has become one of the radicals in the financial auditing, allowing auditors to experience the detailed history of transactions and find anomalies in large data sets.

Case Study Augmented Reality in Financial Analysis

In the field of financial analysis, Citigroup has created an augmented reality (AR) usage through its virtual trading shelf which uses the Microsoft HoloLens. It is an immersive platform that enables traders to work with multi-faceted financial data sets in AR,

and this has improved collaboration and decision-making between traders, resulting in better informed investment decisions. The introduction of AR into the financial auditing practices has proved to have the following main advantages:[30]

- Improved Data Visualization: AR allows financial institutions to visualize more complex data patterns in real-time to assist an analyst in understanding intricate data flows and draw accurate conclusions fast.
- Immersive Virtual Trading: Financial companies are making trading a virtual reality with virtual reality trading workstations. Combining VR and asset management software, the user will have better access to trading algorithms and techniques and a more immersive and efficient trading environment.
- Interactive Finance Education: VR-based virtual training applications provide an interactive and exciting platform to teach the staff and clients finance-related topics and industry trends.

These applications highlight the possible impact of immersive technologies on transforming the process of financial auditing, contributing to a better performance and accuracy of detecting inconsistencies in a multifaceted dataset.

Supply Chain Management

VR has been used in supply chain management to get a visual representation of the flow of commodities and transactions along the network which has increased transparency and coordination among stakeholders.

Case Study Pharmaceutical cannabis productions Virtual Reality-Based Digital Twins

An example of how immersive technologies are used in supply chain management is a study on the application of Extended Reality (XR)-based Digital Twins in the production of pharmaceutical cannabis. The study discusses the design and implementation process of XR-based Digital Twins to help optimize production, enhance resource use, and decision making within the supply chain. Thus, VR incorporated in supply chain management has a number of benefits:[31]

- Improved Data Visualization: VR delivers an immersive environment to visualize complicated data and processes, which will assist supply chain managers gain a better insight and control the processes.
- Enhanced Cooperation: Stakeholders are able to collectively evaluate ledger data within the common virtual environment, and this improves the level of transparency and coordination within the entire supply chain network.
- Streamlined Decision-Making: VR simulations enable supply chain managers to analyze and make evidence-based decisions, which will result in effective and more resilient supply chain processes.

These case studies show the radical effect of VR in supply chain management, which will help to provide better visibility, coordination, and decision-making throughout the network.

Advantages of VR-Improved Digital Ledger Systems

Improved Data understanding

VR provides users with many chances to perceive multidimensional datasets in a way that is not possible in a traditional 2D interface. The intricate ledger systems, transactions and network flows may be spatialized, which allows quicker pattern recognition and anomaly detection. Research shows that data visualization with VR leads to a notable enhancement in cognitive understanding of complex data, especially the financial and operational ones.[32,33] Utilizing spatial perception and interactive discovery, the user will be able to learn more about the dependencies and relationships between the ledgers.

Improved User Engagement

Interactive VR interfaces enhance greater participation because they make interaction with ledger systems interactive and game-based. Virtual representations of transactions can be manipulated, explored, and annotated by users, which is proved to raise motivation, attention, and information retention (Freina and Ott, 2015). Immersion environments usually exceed the standard interface, meaning that VR has the potential to improve satisfaction and learning among ledger users.

Efficient Collaboration

VR environments facilitate active communication between geographically distributed stakeholders. Ledger data can be seen, analyzed and discussed at the same time by sharing a virtual environment. This minimizes misunderstanding and shortens the process of decision making especially in the management of supply chain and financial audit.[35] The shared VR workspaces give participants the opportunity to collectively manipulate virtual objects, simulate scenarios and collectively assure ledger entries thus enhancing operational coordination.

Reduced Errors

VR interfaces are intuitive and interactive, which reduces chances of human mistakes. Visual indicators, virtual walk-through, and live validation diminishes the cognitive load and eliminates errors in data typing or decoding.[36] Auditing and complex financial operations VR has been associated with reduction of error in reporting and compliance with better adherence to reporting and compliance with the overall system reliability.

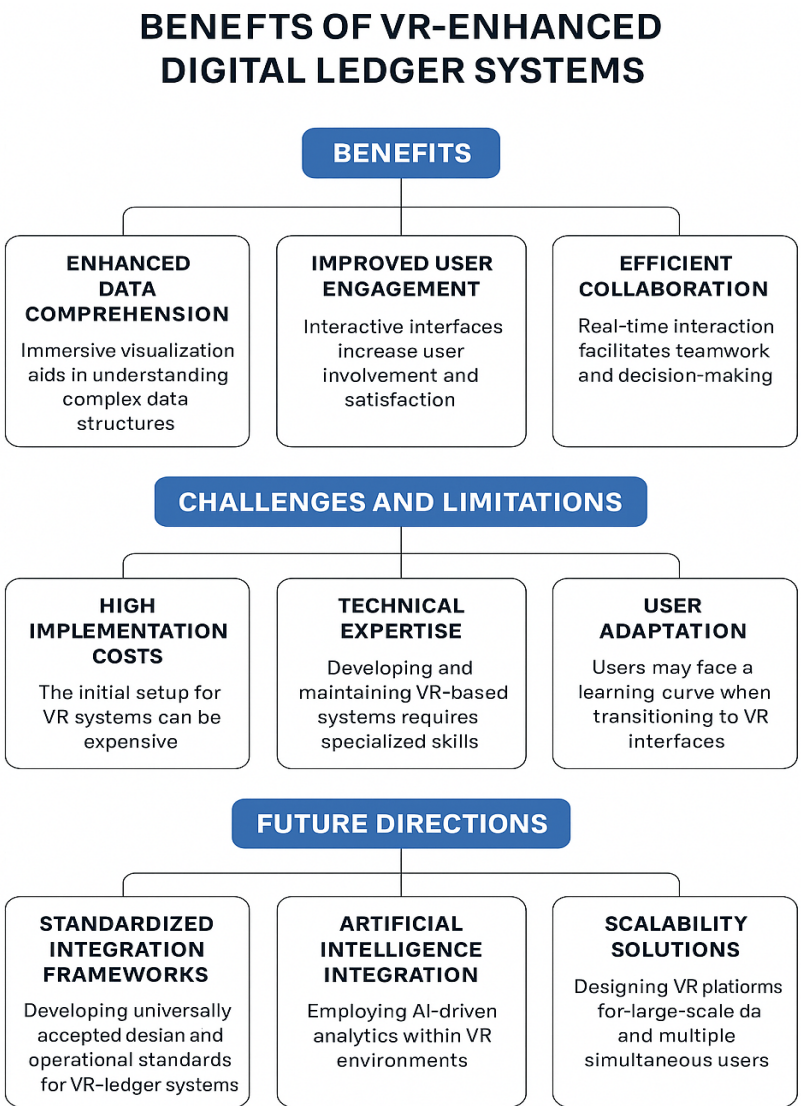


Figure 3. Benefits of VR-Enhanced Digital Ledgers System

Challenges and Limitations

High Implementation Costs

Implementation of VR-based digital ledger systems tend to be costly in terms of finances. Good headsets, motion trackers as well as software development platforms are associated with a significant capital investment. Companies need to weigh possible efficiency benefits against such start-up costs, especially when the organization is expanding to large teams.[37]

Technical Expertise

The creation, introduction, and support of VR-enhanced ledger systems require specific skills in VR and blockchain/digital ledger management. Lack of personnel with expertise could be a constraint to adoption, necessitating the organization to invest in training or outsourced skills.[38]

User Adaptation

Switching to VR interfaces will create a learning curve in users used to the 2D systems. Motion sickness, interaction complexity, and new interaction paradigms are some of the factors that reduce the adoption rate and initial productivity.[34]

Hardware Limitations

The necessary VR hardware, which may comprise headsets, controllers, and the high-performance computing systems, are not available to every organization and user. This weakness can confine its mass application, especially where the cost or resources are sensitive.[39]

Future Directions

The next-generation VR-based digital ledger systems should be developed with regard to several important aspects:

- Uniform Integration Structures: Coming up with design and operational standards compatible across industries and

ensuring VR-ledger systems interoperability, security, and scalability.[32]

- Artificial Intelligence Implementation: AI-based analytics in VR can be used to improve anomaly detection, predictive modeling, and scenario simulation, which will make ledger analysis more productive and informative.[40]
- Scalability Solutions: The ability to design VR platforms that have the capability to process high amounts of data and have numerous users without affecting their performance or user experience. The edge computing and cloud-based VR can make a major contribution to overcome this issue.[35]
- Improved User Experience: Adding adaptive interfaces, haptic feedback, and ergonomic enhancements to make the use of the interface possible over longer durations, and lessen the physical or cognitive load.[38]

CONCLUSION

The streamlined architecture of the digital ledger systems with the use of VR technology is a revolutionary future of data visualization, collaboration, and performance of operations. Immersive interfaces allow users to touch complex datasets in a more intuitive way, to understand them better, to engage them more, and to make better decisions. Although there are obstacles associated with the factors of cost, technical skills, and the availability of hardware, with the help of a proper approach to the design principles, and technological aspects, organizations may manage to afford VR-based ledger systems and implement them successfully. With the ongoing development of the digital economy, these systems will be able to increase the levels of transparency, minimize errors, and promote more efficient and cooperative and resilient organizational processes.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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