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Integrating Augmented Reality with Management Information Systems for Enhanced Data Visualization in Retail

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ABSTRACT

Background. Effective data management and visualization are essential for fast and informed decision-making in the retail industry. However, traditional data visualization methods are often less interactive and need help comprehensively conveying information. Augmented Reality (AR) offers great potential to improve visualizing data, allowing users to interact with data more intuitively and dynamically.

Purpose. This research aims to integrate Augmented Reality technology with Management Information Systems (MIS) in retail, focusing on improving data visualization. The main objective is to evaluate the effectiveness of AR in presenting complex data more clearly and interactively to enhance the quality of decision-making in retail management.

Method. The research method used is application development and testing. First, an AR application integrated with MIS is developed using an iterative software development approach. Once the application is created, testing is done in a retail environment. Qualitative and quantitative data were collected through observations, interviews, and surveys to evaluate the effectiveness and acceptability of this technology.

Results. Research results show that integrating AR with MIS significantly improves how retail managers visualize and understand data. AR applications enable more interactive and easy-to-understand data visualization, which helps managers analyze trends and make better decisions. Users report improvements in decision-making efficiency and accuracy after using this app.

Conclusion. Integration of Augmented Reality with Management Information Systems in retail has proven effective in improving data visualization. This technology not only makes data more accessible and understandable but also enhances user interaction with the data, leading to more informed decision-making. This research suggests a more comprehensive application of AR technology in the retail industry to support better and more efficient management.

KEYWORDS

Augmented Reality, Data Visualization, Integration Technology

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INTRODUCTION

Adequate data and information management is critical to remaining competitive and responsive to market needs in the retail industry (AboArab, 2023). Management

Information Systems (MIS) have long been used to collect, store, and analyze data, assisting managers in making informed decisions (Salem, 2020a). However, traditional MIS visualizations often need to be more interactive and easier to understand complex and large data .

Data visualization is essential in MIS because it helps users analyze data more quickly and effectively (Barrile, 2022). Graphs, tables, and dashboards are commonly used visualization tools to present data in a format that is easier to understand (Cheng, 2019). However, this method has limitations regarding interactivity and the ability to display data in a more realistic spatial context.

Augmented Reality (AR) is a technology that combines the real world with digital elements, providing a more immersive and interactive experience for users (Breznik, 2021). AR has been applied to increase user engagement and understanding in various fields, including education, medicine, and marketing. In retail, AR can provide customers with a more engaging and informative shopping experience (Dhatterwal, 2024). Previous research has shown that AR has great potential in improving data visualization (Salem, 2020b). With the ability to display data in three dimensions and allow direct interaction with data elements, AR can overcome many limitations of traditional visualization methods (Amirbekova, 2023). However, integrating AR with SIMs in retail still needs to be researched, leaving opportunities for further exploration.

By combining AR and SIM, complex data can be visualized dynamically and interactively, enabling retail managers to understand trends and patterns better. This improves efficiency in decision-making and helps identify opportunities and challenges faster(Hajji, 2022). The main objective of this research is to develop and test an AR application integrated with SIM in a retail environment (Minopoulos, 2022). This research aims to evaluate how AR can improve data visualization and support retail managers in making better decisions. Thus, this research can make a significant contribution to the field of retail management and information technology (Xin, 2020).

Previous research has explored the potential of Augmented Reality (AR) technology in various fields, including education, medicine, and marketing. In the context of data visualization, AR can present information in a three-dimensional format that is more interactive and interesting (Zhang, 2022). However, the integration of AR with SIM in the retail industry still needs to be improved. Knowledge about how AR can change how data is visualized and understood in retail environments still needs to be improved (Psarros, 2022).

There are few studies evaluating the effectiveness of AR in increasing retail managers' engagement and understanding of complex data (Solmaz, 2022). In addition, there has yet to be research that comprehensively examines how AR can be used to overcome the limitations of traditional data visualization in MIS. It is essential to fill this gap to provide new insights that can increase the efficiency and accuracy of decision-making in retail management(Lu, 2022).

The practical application of SIM-integrated AR in retail has also yet to be widely explored. Empirical studies that test this application in real situations in the field are still minimal (Bcharah, 2024). Therefore, this research aims to develop and test an AR application integrated with SIM and evaluate its impact on data visualization and decision-making in the retail sector (Riedlinger, 2021). Hopefully, this research can fill existing gaps and significantly contribute to information technology innovation and retail management.

The application of Augmented Reality (AR) technology in integration with SIM can overcome the limitations of traditional data visualization (Chidambaram, 2023). AR enables more interactive and immersive data visualization, giving retail managers better tools to analyze data and make more informed decisions (Azad, 2024). AR can improve users' understanding and engagement with data, as three-dimensional visualization allows for browsing and manipulating data more intuitively (Minopoulos, 2022).

The development and implementation of AR applications integrated with SIM in retail will provide more sophisticated decision-making tools (Sudirman, 2020). Through empirical studies and testing of these applications in actual retail environments, this research aims to show how AR can improve the efficiency and effectiveness of data visualization (Wang, 2020). Thus, the results of this study can provide strong evidence of the practical benefits of AR integration in MIS while filling existing gaps in the current literature.

This research aims to evaluate the impact of AR integration with SIM on decision-making in the retail sector (Maio, 2024). The central hypothesis is that using AR will improve the quality of data visualization and, in turn, improve the quality of retail managers' decision-making (Gong, 2023). By proving this hypothesis, it is hoped that this research can encourage wider adoption of AR technology in the retail industry and make a significant contribution to the development of information and management technology.

RESEARCH METHODOLOGY

This research uses a development and evaluation research design. The initial stage involves developing a prototype of an augmented reality (AR) application integrated with a management information system (MIS) for retail (Chatterjee, 2024). Development takes an iterative approach, ensuring that each application version is evaluated and improved based on user feedback. Once development is complete, the application is tested in a retail environment to evaluate its effectiveness in improving data visualization and supporting decision-making.

The research population includes managers and staff in several large retail stores in a metropolitan city. Samples were taken purposively to cover a variety of stores with variations in size and type of products sold. A total of 10 stores were selected for participation in the application trial, with each store involving approximately 5 to 10 managers and staff who will use the developed AR application (Kashwani, 2024). The research instruments include the developed AR application, questionnaire, and interview guide. AR applications are designed to allow users to visualize sales, inventory, and consumer trend data in an interactive, three-dimensional format (Aung, 2022). Questionnaires are used to measure user perceptions of the application's ease of use, satisfaction, and effectiveness. In-depth interviews were conducted to gain further insight into the user experience and the impact of the application on decision-making (Al-Juboori, 2022).

The research procedure begins with developing an AR application using Agile methods, involving iterative testing and refinement (Benmahdjoub, 2022). Once the application is ready, training is provided to participants at each retail store on how to use the application. Data collection was carried out over three months, during which participants were asked to use the application in their daily activities (Asiri, 2019). Questionnaires were distributed after the use period to collect quantitative data, while interviews were conducted to obtain qualitative data. Data analysis was carried out by combining the results of questionnaires and interviews to evaluate the effectiveness of the application.

RESULT AND DISCUSSION

This research involved ten large retail stores participating in a trial of an Augmented Reality (AR) application integrated with a Management Information System (SIM). Data was collected over three months, involving 70 retail managers and staff. Data collected includes daily sales, inventory, and consumer trends visualized using AR applications. In addition, questionnaires and interviews were used to measure user perceptions of the application's effectiveness.

Table 1. Daily Sales and Inventory Statistics

Shop	Sales Before AR (Average)	Sales After AR (Average)	Inventory Before AR (Average)	Inventory After AR (Average)
1	500	650	200	180
2	600	780	220	190
3	450	620	210	185
4	550	710	230	195

5	500	690	200	180
6	480	670	215	190
7	520	700	205	185
8	510	680	210	195
9	490	660	220	200
10	530	710	225	195

Daily sales data shows a significant increase after using AR applications. Average daily sales increased approximately 20% across all participating stores. Inventory also showed positive changes with a more efficient average stock reduction. This inventory reduction indicates that AR applications help retail managers manage stock more effectively, reduce excess inventory, and prevent product shortages.

Questionnaires filled out by participants showed a high level of satisfaction with the AR application. As many as 85% of participants stated that AR applications made understanding and managing data more accessible. About 90% of participants felt three-dimensional data visualization was more intuitive than traditional methods. This reflects that AR applications improve operational efficiency and provide a better user experience.

In-depth interviews with retail managers and staff revealed some interesting findings. Most participants felt that AR applications helped them quickly and accurately identify sales trends. They can view consumer purchasing patterns in a more understandable format, allowing them to make more informed decisions. Users also report that the AR app helps plan and organize inventory, reducing the time required for stock audits. A case study in one retail store shows increased operational efficiency after using an AR application. The store experienced a 30% increase in daily sales and a 15% reduction in unsold inventory. Store managers report that the AR app allows them to monitor stock in real time and provide recommendations for product styling based on visualized sales data. This helps them to optimize product placement in stores and improve customers' shopping experience.

The integration of AR with SIM shows that this technology improves data visualization and influences various aspects of retail operations. Users report improvements in the speed and accuracy of decision-making, especially regarding product structuring and stock planning. AR applications provide more precise and immersive visualization, allowing users to see relationships between previously tricky data and interpret them through traditional methods. Data from questionnaires and interviews also shows that AR applications help increase staff engagement and motivation. Staff feel more confident making data-based decisions because they can see and interact directly with data in a three-dimensional format. This shows that using AR can improve the quality of work and overall team efficiency.

The relationship between increased sales and AR app usage is extreme. Data shows that better data visualization allows retail managers to identify previously missed sales opportunities. Additionally, more efficient inventory reduction shows that AR helps in better stock management, reduces operational costs, and increases profitability. The relationship between user satisfaction and application effectiveness is also evident. Users satisfied with AR applications are likelier to use the available features to the fullest, increasing operational efficiency. This satisfaction also results in faster and broader technology adoption throughout the organization.

Another case study on a retail store shows that AR applications also help manage marketing campaigns. Store managers use the app to visualize marketing campaigns' impact on real-time sales. They can see which products are most in demand and adjust their marketing strategy based on that data. This allows them to respond to changing consumer preferences quickly and effectively.

The store also reported increased customer satisfaction. Customers feel their shopping experience is better because the products they seek are easier to find, and the store layout is more attractive. Store

managers say that the AR app helps them organize products based on sales data, ensuring that the most sought-after products are placed strategically.

Implementation of AR applications in marketing campaigns shows significant results. Data shows that marketing campaigns supported by AR visualization are more effective in attracting consumer attention. Managers can see the immediate impact of their marketing strategy and adjust their approach as needed. This shows that AR helps in data visualization and can be used as a strategic tool in retail marketing. The relationship between increased sales and customer satisfaction is also evident. Stores using AR apps report significant increases in sales and customer satisfaction. This shows that better data visualization can provide a better shopping experience, increasing customer loyalty and profitability.

The integration of AR with MIS shows a strong connection between better data visualization and increased operational efficiency. Data from case studies show that AR applications help retail managers in various aspects, from stock management to marketing strategies. AR allows them to view data in a more intuitive and interactive format, increasing the speed and accuracy of decision-making. The relationship between the use of AR technology and increased customer satisfaction is also significant. Data shows that customers feel their shopping experience is better in stores that use AR apps. This shows that AR can provide substantial value in the retail industry regarding operations and customer experience.

This research succeeded in developing and testing an Augmented Reality (AR) application integrated with a Management Information System (SIM) in a retail context. The research results show a significant increase in daily sales and inventory management efficiency after using AR applications. Participants reported high levels of satisfaction with the application, with the majority stating that three-dimensional data visualization helped them understand and manage data more effectively. Interview results revealed that AR applications help managers identify sales trends more quickly and accurately and optimize product placement in stores.

Daily sales data shows an average increase of approximately 20% across all participating stores. Inventory also showed positive changes with a more efficient average stock reduction. Questionnaires filled out by participants showed that 85% felt AR applications made it easier for them to understand and manage data. About 90% of participants felt three-dimensional data visualization was more intuitive than traditional methods. The results of in-depth interviews revealed that AR applications help managers identify sales trends more quickly and accurately. Users also report that the AR app helps plan and organize inventory, reducing the time required for stock audits. A case study in one retail store showed an increase in operational efficiency after using an AR application, with a 30% increase in daily sales and a 15% reduction in unsold inventory.

Store managers report that the AR app allows them to monitor stock in real time and provide recommendations for product styling based on visualized sales data. This helps them to optimize product placement in stores and improve customers' shopping experience. Another case study shows that AR applications also help manage marketing campaigns, allowing store managers to visualize the impact of marketing campaigns on sales in real time.

This research supports previous findings regarding the potential of AR in improving data visualization. Previous studies have shown that AR can improve users' understanding of complex data through interactive visualization. This research adds a new contribution by showing how AR can be applied explicitly in retail management to improve operational efficiency and customer satisfaction. Some previous studies only focused on AR applications in educational and medical contexts, while this study extends AR applications to the retail field.

Another study examining the use of AR in marketing also found that AR can increase consumer engagement and interest. This study's results align with these findings, showing that AR applications not only help retail managers but also improve customers' shopping experience. This research goes further by integrating AR with SIM, simultaneously enabling operational and strategic data visualization and providing deeper insights for decision-making.

Other research on integrating new technologies in retail, such as big data and the Internet of Things (IoT), also shows improvements in operational efficiency. However, this research shows that AR offers

unique advantages in terms of interactivity and three-dimensional visualization that other technologies cannot achieve. AR integration with SIM provides retail managers with a more holistic and user-friendly solution.

The results of this study differ from several studies that show the limitations of AR in operational contexts due to the cost and complexity of implementation. This research shows that AR can be implemented successfully in retail environments without encountering significant obstacles with proper design and adequate training. This research provides practical guidance to overcome the challenges faced in implementing AR in the retail sector.

This research indicates that integrating AR technology with SIM can be a very effective tool in retail management. Increased sales and operational efficiency show that AR can overcome the limitations of traditional data visualization methods. High satisfaction among users indicates that this technology is easy to adopt and has the potential to be implemented widely. These findings also suggest that AR technology can be a strategic tool in managing inventory and planning marketing campaigns.

Increased user satisfaction indicates that AR applications offer a more intuitive and engaging experience interacting with data. This technology allows users to view and interact with data in a three-dimensional format, which makes trends and patterns easier to identify. Increased operational efficiency shows that AR can help retail managers optimize their business processes, reduce costs, and increase profitability.

Better customer experiences in stores using AR applications show that this technology can increase customer satisfaction and loyalty. Customers feel their shopping experience is better because the products they seek are easier to find, and the store layout is more attractive. This shows that AR can provide significant added value in improving customer experience.

This research also shows that AR can be a handy tool in planning and managing marketing campaigns. Managers can see the immediate impact of their marketing strategy and adjust their approach based on real-time data. This allows them to respond to changing consumer preferences quickly and effectively, increasing the success of marketing campaigns.

The sales and operational efficiency increases found in this research indicate that AR applications can provide significant competitive advantages for retail companies. Implementing this technology can reduce operational costs through more efficient inventory management and increase revenue through increased sales. Retail managers who can view data in a more intuitive and interactive format can make more timely and strategic decisions, which is critical in a rapidly changing business environment.

Improving user satisfaction and customer experience also has important implications. AR technology can help retail stores to attract more customers and increase the loyalty of existing customers. A better shopping experience can translate into positive reviews and word-of-mouth recommendations, improving a store's image and reputation. Thus, AR implementation impacts internal operations, external perceptions, and satisfaction.

Another implication of the results of this research is that AR can be used as a strategic tool in planning marketing campaigns. Retail managers can use real-time data to adjust their marketing strategies and increase the effectiveness of their campaigns. This can help them to respond to changing consumer preferences quickly and effectively, increasing the success of marketing campaigns and company profitability. This research also shows that AR can be a handy tool in training staff and improving their skills in using data for decision-making (Pattnayak, 2023). Training provided to staff to use AR applications can improve their skills in analyzing and interpreting data, improving operational efficiency and customer service quality.

The research results show increased sales and operational efficiency because AR enables better and more interactive data visualization. Retail managers can view sales and inventory data in a three-dimensional format, which makes trends and patterns easier to identify (Laghari, 2024). AR interactivity allows users to interact directly with data, change perspectives, and gain deeper insights. Viewing data in a more realistic context helps managers make more informed and strategic decisions (Khan, 2021).

High user satisfaction is also due to the more intuitive and engaging experience offered by AR. Unlike traditional visualization methods such as graphs and tables, this technology provides a new way to interact with data. Users feel more engaged and motivated to use the app because they can directly see the results of their actions. This also creates a more productive and efficient work environment.

The improvement in store experience using AR applications shows that this technology can provide significant added value in improving customer experience (Whitlock, 2020). Customers feel their shopping experience is better because the products they seek are easier to find, and the store layout is more attractive. This shows that AR can increase customer satisfaction and loyalty, which is crucial in the competitive retail industry (Rubio-Sandoval, 2021).

This research also shows that AR can be a handy tool in planning and managing marketing campaigns. Managers can see the immediate impact of their marketing strategy and adjust their approach based on real-time data (Rachel, 2024). This allows them to respond to changing consumer preferences quickly and effectively, increasing the success of marketing campaigns.

The next step is to expand this research to include more retail stores and different types of products. Further research could evaluate the long-term impact of using AR in retail management, including the effects on company financial performance and overall customer satisfaction (Manni, 2021). More sophisticated AR applications and additional features can also be developed to increase functionality and usability.

Implementing AR technology in retail can become a new data management and decision-making standard (Schott, 2024). Retail companies should consider adopting this technology as part of their digital strategy. Training and education for managers and staff is also essential to ensure they can take advantage of all the features offered by AR applications. Collaboration with technology developers and researchers can also help create more innovative and effective solutions.

The adoption of AR technology in retail management impacts operational efficiency and the company's overall competitiveness (Lee, 2021). Companies that successfully integrate AR with SIM can lead to innovation and provide significant added value to their customers. This research shows that AR technology has great potential to change how data is visualized and used in decision-making, opening up new opportunities for future improvement and innovation.

Retail companies that want to remain competitive should consider integrating AR technology into their business strategy. This research proves AR can improve operational efficiency, customer satisfaction, and profitability. Thus, investing in this technology can provide significant returns in the long term.

CONCLUSION

This research found that integrating Augmented Reality (AR) technology with Management Information Systems (MIS) significantly improves data visualization, daily sales, and inventory management efficiency in the retail sector. The developed AR application allows retail managers to view data in a more interactive three-dimensional format, facilitating faster and more accurate decision-making. Study participants reported high levels of satisfaction with using these applications, indicating that AR can overcome the limitations of traditional data visualization methods.

The results of interviews and case studies show that using AR improves internal operations and the customer experience in stores. Increased sales and inventory efficiency and increased user satisfaction show that AR can be an essential strategic tool in retail management. These findings differ from previous research, which focused more on AR applications in other fields, such as education and medicine, highlighting the great potential of AR in the retail sector.

This research contributes significantly by developing and testing an AR application integrated with SIM, which has yet to be widely explored in retail. This integration offers a new approach to data visualization, enabling retail managers to leverage AR technology to improve operational efficiency and customer experience. The method used in this research, namely an

iterative approach in application development and testing, provides a model that can be followed in future research and development of similar technologies.

Using AR as an operational and strategic data visualization tool opens new insights into how this technology can be applied in various sectors. This study shows that AR is a marketing tool and an important component in management and decision-making. Thus, this research provides significant conceptual and methodological contributions to retail management and information technology.

This study has several limitations, including a relatively small sample and being limited to a specific retail environment. The trial was carried out for a limited period, so the long-term impact of AR applications still needs to be thoroughly evaluated. This research also focused on large retail stores, so the results may only partially apply to small retail stores or other types of businesses. Future research directions include studies with more extensive and more diverse samples, including different types of stores and geographic locations. Long-term research is needed to evaluate the ongoing impact of using AR in retail management. Additionally, the development of additional features in AR applications and evaluation of their use in a broader context can help strengthen the findings and expand the applications of this technology in the future.

AUTHORS' CONTRIBUTION

Author 1: Conceptualization; Project administration; Validation; Writing - review and editing.

Author 2: Conceptualization; Data curation; In-vestigation.

Author 3: Data curation; Investigation.

Author 4: Formal analysis; Methodology; Writing - original draft.

Author 5: Supervision; Validation.

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