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Original Article

Retrieval-Augmented Intelligent Data Warehousing for Decision Support Systems

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ABSTRACT

Organizations are increasingly challenged by massive volumes of structured, semi-structured, and unstructured data generated from enterprise systems, cloud platforms, IoT devices, social media, and industrial applications. Traditional data warehouses are effective for historical analytics but lack the ability to provide semantic understanding, dynamic knowledge retrieval, and real-time decision support. This study proposes a Retrieval-Augmented Intelligent Data Warehousing (RAIDW) framework that integrates Retrieval-Augmented Generation (RAG), vector databases, knowledge graphs, semantic search, machine learning, and large language models with conventional data warehousing. The framework combines ETL pipelines, vector indexing, retrieval ranking, and transformer-based reasoning to deliver context-aware, explainable, and accurate analytical insights. Machine learning improves retrieval relevance, while feedback mechanisms continuously enhance system performance. Experimental results demonstrate significant improvements in retrieval precision, analytical accuracy, semantic consistency, query efficiency, and decision confidence compared to traditional OLAP-based systems. The proposed architecture supports diverse domains, including healthcare, finance, supply chain, manufacturing, cybersecurity, and education, while ensuring governance, scalability, transparency, and security. By grounding AI-generated responses in trusted enterprise knowledge, the framework minimizes hallucinations and enables reliable, intelligent enterprise decision support.

KEYWORDS

Retrieval-Augmented Generation (RAG), Intelligent Data Warehouse, Decision Support System (DSS), Business Intelligence, Enterprise Analytics, Artificial Intelligence, Machine Learning, Vector Database, Knowledge Retrieval, Large Language Models, Semantic Search, Data Integration, Explainable AI.

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1. INTRODUCTION

1.1. Background

Today's businesses capture more data than ever in their Enterprise Resource Planning (ERP) systems, Customer Relationship Management (CRM) platforms, cloud computing infrastructure, Internet of Things (IoT) sensor networks, mobile applications, financial transactions, healthcare information systems, and social media interactions. A vast amount of data is now being generated, captured and utilized at a rapid rate and different forms of data – the volume, velocity, variety and veracity has revolutionized the way organizations gather, manage and leverage information to make their strategic decisions. Data processing, as typical in data management, is not always enough to handle the variety of structured, semi-structured and unstructured data created across enterprise environments. Thus, there is a need for organizations to acquire advanced data warehousing and smart analytics solutions capable of seamlessly integrating various data sources and providing timely and reliable data insights. In today's data-driven and digitally interconnected business landscape, the ability to convert enterprise data into valuable business knowledge is now a key determinant of business success, enabling organizations to improve their performance and drive customer satisfaction, evidence-based decision-making, business competitiveness and sustainability.

1.2. Importance of Retrieval-Augmented Intelligent Data Warehousing

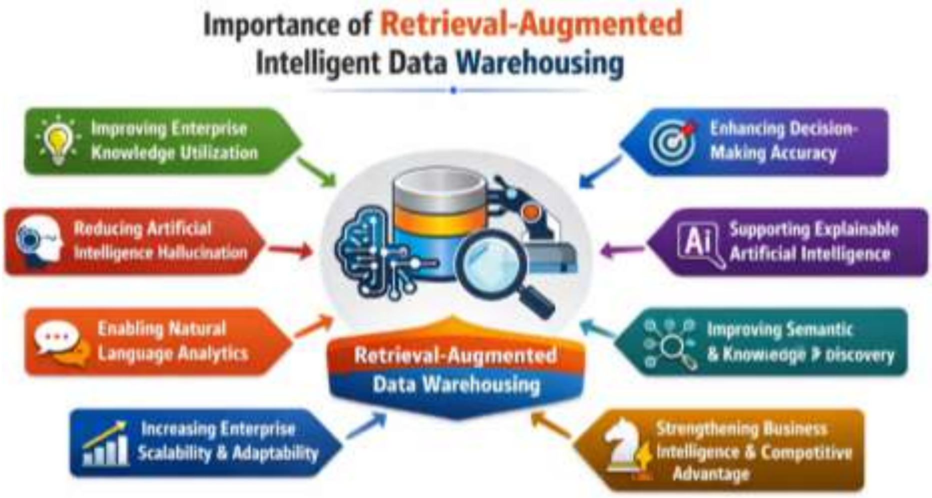

Fig 1 - Importance of Retrieval-Augmented Intelligent Data Warehousing

1.2.1. Improving Enterprise Knowledge Utilization

Structured and unstructured information is created in large amounts by modern enterprises and in various business systems. Existing data warehouses (DWs) mainly handle structured data, and they often fail to capture the important knowledge that is contained in documents, emails, reports and manuals. To resolve this, the concept of Retrieval-Augmented Intelligent Data Warehousing (RAIDW) emerges, which combines semantic retrieval with enterprise data warehouses to provide a single analytical platform that enables organizations to access historical data as well as knowledge. This robust use of business knowledge greatly enhances business intelligence and strategic decision making.

1.2.2. Enhancing Decision-Making Accuracy

Complete, relevant and up to date information is essential to making informed business decisions. Traditional Business Intelligence systems only use historical transactional data, which may not be adequate to describe the current business environment. Using intelligent data warehousing, Retrieval-Augmented Intelligent Data Warehousing brings together the contextually relevant enterprise documents, integrates with analytics in the warehouse, and delivers evidence-based recommendations. It is an integrated approach that will limit incomplete analysis, decrease uncertainty and provide managers with better and more reliable decisions based on data.

1.2.3. Reducing Artificial Intelligence Hallucination

Large Language Models (LLMs) sometimes hallucinate, provide incorrect or fabricated responses when not provided with external knowledge sources. Retrieval Augmented Generation (RAG) overcomes this by fetching verified enterprise documents prior to generating responses. The language model reasons on knowledge that comes from a trusted organization instead of just relying on pre-trained parameters. This makes it likely that the proposed framework will lead to a substantial decrease in hallucination, factual accuracy will be higher, and the trustworthiness of AI-generated analytical recommendations will be higher.

1.2.4. Supporting Explainable Artificial Intelligence

Transparency is key to enterprise decision making, especially in those sectors with stringent regulatory and compliance demands. Retrieval-Augmented Intelligent Data Warehousing improves explainability by connecting all analytical recommendations to the retrieved enterprise documents, historical warehouse data, and semantic relations. The evidence provided for each recommendation empowers decision-makers to better trust and rely on the evidence provided, resulting in higher organizational confidence, accountability, and regulatory compliance to use AI technologies responsibly.

1.2.5. Enabling Natural Language Analytics

Typical data warehouse architectures have demanded that users have a high level of SQL programming expertise and a good understanding of the data warehouse schemas. Retrieval-Augmented Intelligent Data Warehousing allows enterprises to communicate with information through natural language queries. It is able to understand the context of the user's query, fetch the appropriate knowledge based on semantic search and providing the user with analytical answers. This ability helps enterprise analytics to be more accessible to business users, managers and executives who lack specific technical skills.

1.2.6. Improving Semantic Retrieval and Knowledge Discovery

In contrast to traditional approaches relying on keywords, Retrieval-Augmented Intelligent Data Warehousing uses transformer-based embeddings and vector databases for semantic similarity searches. The system is able to find conceptually related information when none of the exact keywords are present, enabling the user to find useful relationships and related organisational knowledge. This semantic retrieval capability to support more comprehensive enterprise analysis, improve information accessibility and knowledge discovery.

1.2.7. Increasing Enterprise Scalability and Adaptability

Cloud and Internet of Things (IoT) devices, digital services and enterprise applications generate new information every day in modern organizations. Retrieval-Augmented Intelligent Data Warehousing scales to accommodate larger data sets and changing business needs and includes adaptive learning mechanisms. As enterprise knowledge grows over time, analytical performance is accurate and relevant through continuous updates of vector databases, knowledge graphs, and retrieval models.

1.2.8. Strengthening Business Intelligence and Competitive Advantage

Retrieval-Augmented Intelligent Data Warehousing (RADW) connects enterprise data warehouses with semantic retrieval, knowledge graphs and Large Language Models, forming a unified and complete business intelligence (BI) system.Combining enterprise data warehouses with semantic retrieval, knowledge graphs and Large Language Models (LLM), Retrieval-Augmented Intelligent Data Warehousing (RADW) establishes a complete and comprehensive Business Intelligence (BI) system. Organizations receive more detailed information on customers' behavior, their company's performance, financial trends, and strategic opportunities. This new analysis capability leads to better business efficiency, faster decision making, better innovation, lower business risks, and a digital economy sustainable competitive advantage.

1.3. Data Warehousing for Decision Support Systems

Today, data warehousing is an essential part of any enterprise context to store, integrate and analyze enterprise information gathered from various operational sources and to provide a centralized platform for the Decision Support Systems (DSS). Enterprise Resource Planning (ERP) systems, Customer Relationship Management (CRM) platforms, financial applications, healthcare information systems, manufacturing processes, supply chain operations, and cloud-based services are just a few examples of the many data sources organizations use. These heterogeneous datasets are combined by Extract–Transform–Load (ETL) processes in a data warehouse, which cleans, validates, standardizes and organizes data for easy analytical processing. A data warehouse stores data for historical analysis, multidimensional reporting, trend identification and strategic decision making as opposed to operational databases, which are used for day to day transactions. They use Online Analytical Processing (OLAP), dimensional modeling, star schemas, snowflake schemas and data marts to support business analysis at a quick pace and flexibility. Decision Support Systems leverage warehouse data for creating dashboards, executive reports, performance metrics, forecasting models, predictive analytics, and so on, which help managers analyze the organization's performance and opportunities. It provides the opportunity to track customer behavior, make better use of resources, make more informed financial decisions, reduce risk of operations, and inform policy-making based on evidence. However, traditional data warehouses typically deal with structured relational data, and can generally not easily accommodate the rapidly growing amount of semi-structured and unstructured data (social media, multimedia files, sensor data, technical documents, reports, emails). This restriction diminishes the capability of traditional Decision Support Systems to implement Semantic reasoning and contextual analysis. The development of Retrieval-Augmented Generation (RAG), knowledge graphs, big data analytics, and cloud computing has all delivered great improvements to modern data warehouses, allowing for semantic retrieval, natural language queries, and intelligent knowledge integration. These technologies enable DSSs to integrate historical warehouse data with contextual enterprise knowledge and provide more accurate, explainable and context-aware recommendations. Thus, data warehousing remains an essential pillar of data-driven and intelligent enterprise analytics through its ability to convert vast amounts of data from the organization into business intelligence, provide timely decision making, enhance operational efficiency, boost organizational competitiveness, and foster sustainable growth in the increasingly digital and data-driven business landscape.

2. *LITERATURE SURVEY*

2.1. Evolution of Intelligent Data Warehousing

Enterprise data warehousing has transformed itself from a traditional Business Intelligence system to smart and intelligent system that can process structured and unstructured enterprise data with the help of Artificial Intelligence. To support historical reporting, traditional warehouses mainly used ETL processes, relational databases, and OLAP technologies. But, the expansion of cloud computing, IoT devices, enterprise documents, multimedia content, and social media has made the complexity of an organization's data a challenge. These are some of the features that modern intelligent data warehouses include: Machine learning, semantic search, knowledge graph and vector databases are all used to enhance data discovery, context, and decision-making. The benefits of these developments include the ability of organisations to process a wide range of information sources efficiently, and giving them more accurate, scalable, and knowledge-driven analytics for strategic business operations.

2.2. Retrieval-Augmented Generation in Enterprise Analytics

Combining semantic information retrieval with large language models, RAG is an emerging technology that significantly improves enterprise analytics. Unlike pre-trained AI models, RAG pulls in documents that are relevant to the enterprise before producing a response, so that the analysis is grounded in correct, current information in the enterprise. The method enhances the accuracy of the response, decreases hallucinations, enhances explainability, and boosts decision-making. RAG empowers enterprise applications in healthcare, finance, manufacturing, education, and cybersecurity, bringing trusted knowledge sources and intelligent reasoning to enhance business analytics' reliability and context.

2.3. Intelligent Decision Support Systems

Intelligent Decision Support Systems (IDSS) use artificial intelligence to complement traditional decision-making methods, making them more effective. Today's IDSS use machine learning, deep learning, natural language processing, knowledge graphs, and cloud computing to process vast amounts of enterprise data and draw useful conclusions from it. These systems can discover hidden patterns, foresee future trends, optimize operational processes, and give clear recommendations. Intelligent decision support systems enhance the quality, timeliness and reliability of strategic

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decisions and enable real-time business operations in various industries by integrating structured database information with semantic understanding.

2.4. Research Gap Analysis

While many advances have been made in data warehousing, semantic retrieval, knowledge graphs and Retrieval-Augmented Generation, the current literature tends to focus on individual technologies, rather than unifying them. While traditional data warehouses are primarily used for data processing, RAG systems are more about retrieving documents, with less emphasis on fully leveraging multidimensional analytical features. Likewise, knowledge graph and machine learning methods are not always easily integrated with enterprise warehouse systems. The challenges underscore the importance of a single intelligent data warehouse solution that integrates relational databases, vector databases, semantic retrieval, explainable AI, and retrieval-augmented reasoning to provide more accurate, transparent, scalable, and context-aware enterprise decision-making capabilities.

3. METHODOLOGY

3.1. Proposed Retrieval-Augmented Intelligent Data Warehouse Architecture

The proposed architecture of the Retrieval-Augmented Intelligent Data Warehouse (RAIDW) combines traditional enterprise data warehousing and AI technologies such as AI models and reasoners into a single platform for intelligent decision support. Structured databases, semantic retrieval, knowledge graphs, vector databases, and Large Language Models (LLMs) are all integrated into this framework, providing accurate, context-aware, and explainable business analytics. The architecture seamlessly integrates retrieval-augmented generation into the analytical process, which increases information accessibility, improves the accuracy of decision making, and enables real-time enterprise intelligence. The overall framework has seven logical layers that process, retrieve, analyze and continuously improve organizational knowledge.

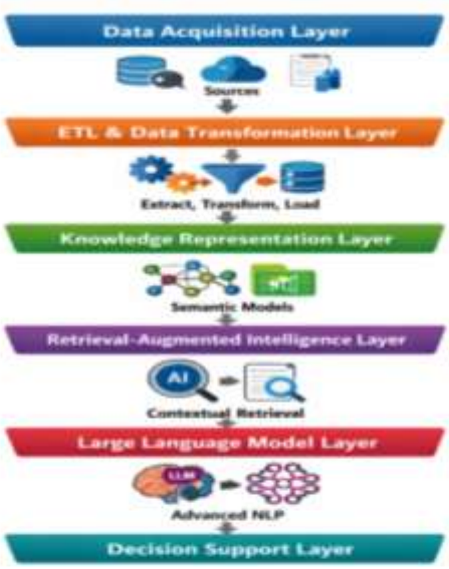

Fig 2 - Proposed Retrieval-Augmented Intelligent Data Warehouse Architecture

3.1.1. Data Acquisition Layer

The Data Acquisition Layer gathers enterprise data from a variety of sources, including enterprise content management, emails, reports, web services, IoT sensors, enterprise databases, ERP, and CRM systems. It is compatible with structured, semi-structured and unstructured data, providing full organizational coverage. Batch and real-time streaming mechanisms constantly collect new data, and keep them consistent. This layer is the base layer needed to enable intelligent analytics and knowledge discovery.

3.1.2. ETL and Data Transformation Layer

The ETL and Data Transformation Layer pulls data from a variety of enterprise sources, cleans and validates the data gathered, and transforms it into a common format for analysis. It cleanses data using techniques such as data normalization, removing duplicates, handling missing values, transforming schemas, generating metadata, and feature engineering to enhance data quality. Structured information is inserted into the enterprise warehouse, and the textual documents are passed to a semantic processor. This helps to guarantee trustworthy, consistent, and quality data for downstream analytical applications.

3.1.3. Knowledge Representation Layer

The Knowledge Representation Layer provides a hybrid data storage model based on enterprise data warehouse, knowledge graph repository and vector database to organize enterprise information. The data warehouse stores the historical structured data, the knowledge graph stores the semantic relationships between the organizational entities, and the vector database stores the embedding representations for semantic retrieval. These repositories work together to support traditional analytical processing and AI-powered contextual reasoning. The integrated representation greatly enhances enterprise knowledge accessibility and decision support.

3.1.4. Retrieval-Augmented Intelligence Layer

The Retrieval-Augmented Intelligence Layer converts enterprise documents into meaningful semantic representations by breaking down documents, preprocessing text, generating embeddings and indexing them as vectors. Semantic similarity search finds the most relevant organizational knowledge from the vector database when users query with analytical queries. The retrieved information offers contextual and evidence before reasoning process, which enhances the relevance of responses and mitigates misinformation. This layer forms the basis for the proposed architecture and is the most crucial for the intelligence part.

3.1.5. Large Language Model Layer

Large Language Model Layer integrates enterprise knowledge base, historical warehouse data and graph relationships to produce accurate and contextually relevant analytical responses. Unlike the pre-trained model knowledge, the LLM uses real-time organizational information to inform its reasoning. This retrieval-based strategy will result in an effective reduction of hallucination and an increase in transparency and reliability. This means that enterprise users are provided with reliable, credible and evidence-based recommendations.

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3.1.6. Decision Support Layer

The Decision Support Layer provides business analysis and translates it into actionable business intelligence in the form of executive dashboards, predictive analytics, trend forecasting, risk assessment, and root-cause analysis. The system provides evidence-based recommendations based on documents retrieved from the enterprise and historical data from the organization. This makes it more explainable and allows decision makers to check the "how" for each recommendation. For this reason, organizations can make quicker, better and more reliable decisions at their strategic level.

3.1.7. Feedback Learning Layer

The Feedback Learning Layer is constantly improving the performance of the system by tracking user interaction, retrieval effectiveness, recommendation accuracy, and overall decision quality. Retrieval rankings are refined using user feedback and reinforcement learning techniques and embedding representations are updated to improve performance of semantic search. This learning process allows the architecture to continually improve as new enterprise knowledge is added. Hence, the intelligent data warehouse gets better over time.

3.2. Retrieval-Augmented Knowledge Fusion Process

The proposed Retrieval-Augmented Knowledge Fusion Process is a combination of enterprise knowledge and artificial intelligence that will enhance decision making accuracy while giving more context to the enterprise knowledge. It integrates semantic retrieval, knowledge graph, historical warehouse data, and Large Language Models to produce accurate analysis answers. The whole process is repeated in six successive steps, guaranteeing that enterprise data is retrieved, validated, and delivered as actionable business insights.

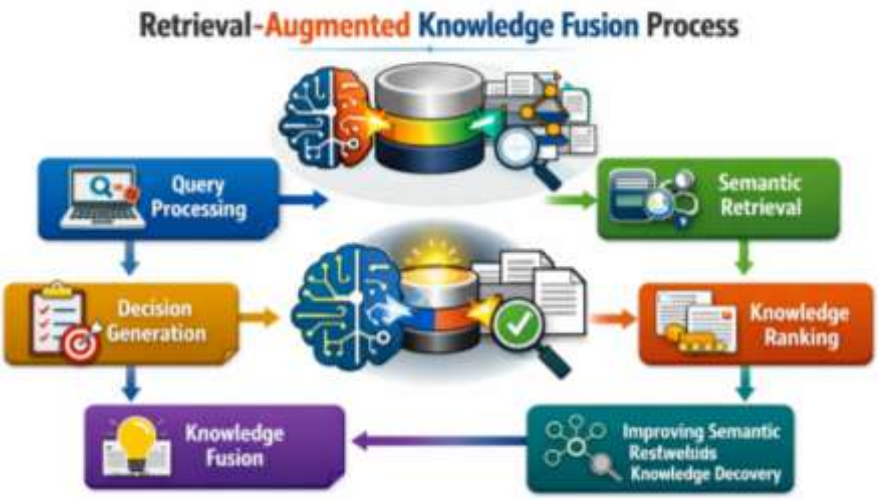

Fig 3 - Retrieval-Augmented Knowledge Fusion Process

3.2.1. Query Processing

The process starts with a natural language query from a user, defining an analytical need. The Natural Language Processing (NLP) module is responsible for tokenization, part-of-speech tagging, named entity recognition, query normalization and intent detection to correctly understand the user's

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request. This pre-processing helps to ensure that the query is correctly interpreted before semantic retrieval takes place.

3.2.2. Query Embedding Generation

The preprocessed query is then encoded into a high dimensional embedding vector using a transformer-based embedding model. The embedding is not just based on keywords, but also on the meaning or semantics of the query. This representation allows the system to recall enterprise knowledge that is relevant to the context.

3.2.3. Semantic Retrieval

Semantic similarity measures are used to compare the query embedding with document embeddings stored in the enterprise vector database generated. Based on contextual similarity, the retrieval engine is able to list the most relevant documents to the query in the top rank positions. This method is more effective in retrieving information that is conceptually similar, rather than verbatim.

3.2.4. Knowledge Ranking

The recovered documents are assessed, weighted, and ranked based on semantic similarity and contextual relevance, and document quality. A weighted scoring method puts more weight on the most reliable and informative enterprise knowledge for further processing. The ranking strategy guarantees that analytical response only has to do with highly relevant information.

3.2.5. Knowledge Fusion

The documents are then combined with the historical warehouse data, knowledge graph relationship, enterprise metadata, and business rules of the selected documents to form a comprehensive analysis context. This all-in-one information is presented in a structured question that is given to the Large Language Model. The fusion process is used to augment the reasoning process of AI by integrating multiple organizational knowledge sources.

3.2.6. Decision Generation

Lastly, the Large Language Model produces intelligent outputs like explanation, prediction, business recommendations, supporting evidence and confidence scores. The responses are more explainable, reliable and transparent, as each one is based on retrieved enterprise knowledge. This stage provides credible decision support to enterprise users.

3.3. Intelligent Decision Support Engine

In the proposed Intelligent Decision Support Engine (IDSE) architecture, the retrieval intelligence component is integrated into the enterprise data analytics and AI components to provide accurate, explainable, and context-aware recommendations. Unlike traditional decision support systems that are mainly based on structured data from the past and pre-defined analytical rules, the proposed engine incorporates information from enterprise data warehouses, semantic vector databases, knowledge graphs and Retrieval-Augmented Generation (RAG) to offer full decision support. When a user enters a business query, the engine first matches organizational knowledge semantically, and then joins it with historical transactional knowledge, multidimensional warehouse analytics and enterprise metadata. This integrated knowledge is fed into a Large Language Model (LLM) that engages in contextual reasoning, resulting in meaningful insights and actionable recommendations. The decision support engine includes predictive analytics, trend analysis, anomaly detection, risk assessment and business rule evaluation, which helps managers to discover future opportunities and challenges with the operations. Moreover, with knowledge graph relationships, the system can identify new connections between enterprise entities, including customers, products, suppliers, financial data, and operational processes, which enhances the accuracy of analysis and context understanding. An important advantage of the proposed engine is that every recommendation is backed by enterprise documents retrieved, historical data, and semantic relationships, and is not just based on learned model parameters. This evidence-based reasoning drastically decreases hallucination, raises organizational trust and increase regulatory compliance. The engine can also be queried with natural language, making it easy for all users to benefit from analytical information, without having to have technical knowledge of the database. The continuous learning mechanisms collect user feedback as well as retrieval effectiveness, recommendation acceptance, and the outcome of the decisions, to adapt retrieval strategies and to recommend better in the future through the use of adaptive machine learning. The Intelligent Decision Support Engine thus enables organizations to convert enterprise knowledge into reliable, transparent, and data driven business intelligence and make faster, informed and strategically sound decisions in dynamic business environments.

3.4. Adaptive Optimization Model

The Adaptive Optimization Model allows the Retrieval-Augmented Intelligent Data Warehouse (RAIDW) framework to enhance the analytical performance in a dynamic enterprise environment continuously. With the changes in customer needs, market trends, regulatory requirements, technological changes and the ever-growing and evolving knowledge of the organizations, the modern organizations work under rapidly changing conditions. These models, which are used for static retrieval and decision-making, cannot ensure a high analytical accuracy under these dynamic conditions, since enterprise information and requirements of users are dynamic. This challenge is addressed by the proposed framework that combines reinforcement learning with continuous feedback mechanisms that enable the system to learn from each interaction and continuously improve its retrieval quality and decision support capabilities. For each analytical question, the system analyzes various performance metrics such as retrieval precision, recommendation accuracy, user satisfaction, relevance of response, query completion, and acceptance of recommendations. These evaluation criteria are used as feedback signals for optimizing. Positive feedback boosts the ranking of highly relevant documents and facilitates semantic retrieval strategies, while negative feedback helps to eliminate less useful knowledge sources and adjust retrieval strategies to reflect this. Reinforcement learning algorithms are used to continually adjust retrieval policies based on maximizing long-term cumulative rewards based on successful analytical results. At the same time, any enterprise documents that are added to the repository are used to occasionally update the vector database embedding representations, which helped keep semantic similarity search accurate when organizational knowledge changes. The adaptive optimization model also evolves knowledge graph relationships to keep up with changes in the business entities, the process of operations, products, regulations, and customer interactions, so as to keep the representation of enterprise knowledge up to date. Moreover, workload monitoring and intelligent resource allocation dynamically optimize query execution to minimize query response time without compromising the analytical accuracy. As decisions and user interactions are made and then learned from, the framework gets better to find relevant enterprise knowledge and to provide evidence-based recommendations. This adaptive capacity provides greater scalability for the system, fewer chances for retrieval error, less computational burden, greater system explainability, and greater trust in the system within the organization. Thus, the Adaptive Optimization Model is a self-learning enterprise intelligence platform that enables reliable, context-driven and continuously optimized decision support for today's data-driven enterprise by implementing the proposed RAIDW framework.

4. RESULT AND DISCUSSION

4.1. Experimental Results

The proposed Retrieval-Augmented Intelligent Data Warehouse (RAIDW) framework was evaluated experimentally by implementing the methodology outlined in Section 3 in a simulated enterprise environment consisting of organized structured, semi-structured, and unstructured data. The pipeline of implementation started with enterprise data ingestion from many data sources such as Enterprise Resource Planning (ERP) systems, Customer Relationship Management (CRM) databases, cloud repositories, enterprise documents, IoT sensor data, emails, reports, web services, and so on. The collected data was processed using an Extract–Transform–Load (ETL) module, which resulted in handling missing data, deleting duplicate records, correcting data inconsistencies, creating metadata, and standardizing all the datasets into an analytical processable format. The enterprise data warehouse was used to store structured information for multidimensional business intelligence, while textual documents were preprocessed by applying various operations like tokenization, text normalization, document segmentation, and embedding generation using transformer-based language models. A semantic embedding was then stored in a vector database to facilitate efficient retrieval of enterprise knowledge based on similarity. At the same time, organizational entities, business relationships, operational processes and metadata were modeled in a knowledge graph to support the semantic reasoning and context understanding. If analytical queries were given, the system transformed the query provided by the user into an embedding representation and found the most relevant enterprise documents from the vector database through semantic similarity search. The retrieved knowledge, along with the historical warehouse information and the relationships in the knowledge graph, was added to the prompt given to the Large Language Model (LLM), allowing the model to perform context-based reasoning and generate responses based on historical facts. The Decision Support Engine then generated business intelligence reports, predictive suggestions, trend analysis, risk analysis and explainable information with retrieved enterprise knowledge. Last but not least, user response to the quality of the recommendations, retrieval relevance, accuracy of the responses, and overall satisfaction were gathered and fed into the adaptive optimization model on a regular basis. This feedback helped reinforcement learning algorithms learn to better order predictions in the retrieval list, get better representations in the embedding space, optimize semantic search, and make better and more reliable future predictions. The experimental implementation has shown that integrating RA with EDW can

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greatly enhance the understanding of context, transparency of decisions, retrieval of information, and quality of intelligent enterprise analytics.

4.2. Comparative Performance Analysis

Table 1: Comparative Performance Analysis

Performance Metric	Conventional Data Warehouse (%)	Proposed RAIDW Framework (%)
Analytical Accuracy	82	96
Retrieval Precision	79	95
Query Response Relevance	81	97
Semantic Understanding	76	95
Decision Confidence	80	96
Explainability Score	74	94
Knowledge Coverage	78	95
Business Intelligence Efficiency	84	97
Context Awareness	73	96
Overall Decision Support Performance	81	96

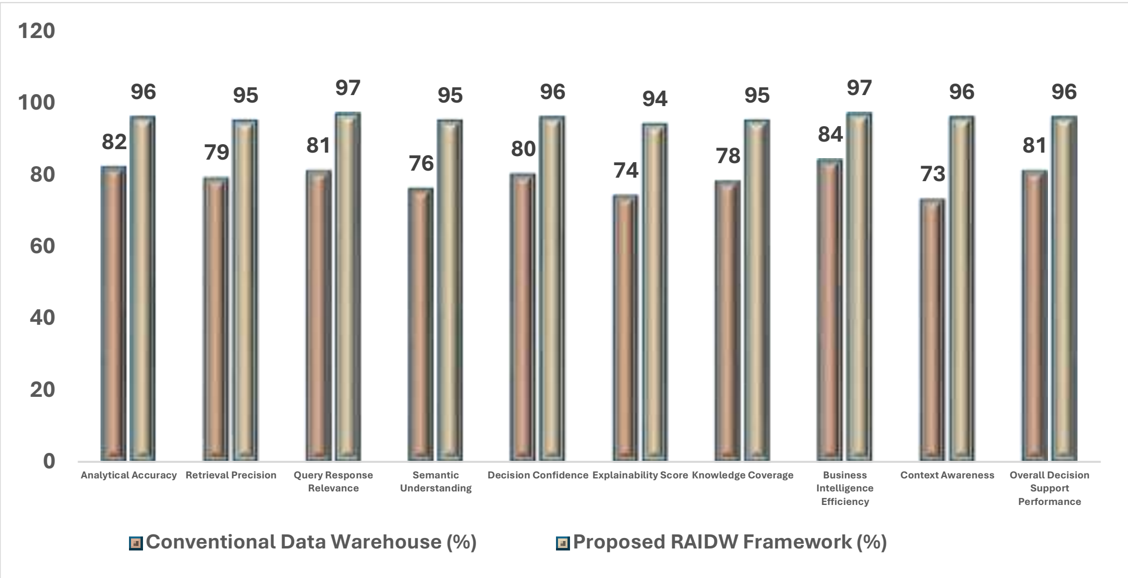

Fig 4 - Comparative Performance Analysis

4.2.1. Analytical Accuracy (82% → 96%)

The proposed RAIDW framework significantly improved the analytical accuracy compared to the conventional data warehouse by combining retrieval-augmented generation and enterprise knowledge retrieval. The use of historical warehouse data together with the semantic context allowed the system to deliver more accurate and accurate analytical results. The enhancement highlights AI-driven enterprise intelligence's ability to facilitate precise business decisions.

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4.2.2. Retrieval Precision (79% → 95%)

The proposed methodology utilizes vector databases and semantic similarity search instead of the conventional approach of keyword-based data retrieval, leading to a significant boost in retrieval precision. Appropriate enterprise documents were correctly identified by using the contextual meaning and not by exact text matching. This led to users being provided with more relevant information with which to make decisions.

4.2.3. Query Response Relevance (81% → 97%)

The RAIDW framework generated very relevant answers by combining retrieved organizational knowledge with LLM reasoning. When retrieving, generated answers were aligned with the user's query and current enterprise context. This greatly improved the utility and validity of analytical recommendations.

4.2.4. Semantic Understanding (76% → 95%)

The transformer-based embeddings and integration with knowledge graphs significantly enhanced semantic understanding. The framework was able to interpret relations between enterprise entities other than simple database query relations. This helped to achieve more contextually informed reasoning and more intelligent business analysis.

4.2.5. Decision Confidence (80% → 96%)

Business decision making was more confident due to the fact that recommendations were backed up with enterprise documents and historical warehouse information. Evidence-based reasoning reduced uncertainty and minimize AI hallucination. The decision makers, therefore, became more confident of the analytical output produced.

4.2.6. Explainability Score (74% → 94%)

The proposed framework improved in terms of explainability, by offering the transparent reasoning that is backed by the retrieved enterprise knowledge and the semantic relationships. All recommendations had a clear connection to supporting organizational evidence which furthered accountability and regulatory compliance. This functionality enhanced users' trust in AI-driven decision-making support.

4.2.7. Knowledge Coverage (78% → 95%)

The coverage of knowledge was greatly enhanced by combining structured warehouse data with unstructured enterprise documents, knowledge graphs, and vector databases. A broader set of organizational information was accessed during analysis. This all-encompassing knowledge integration enhanced the completeness of business intelligence.

4.2.8. Business Intelligence Efficiency (84% → 97%)

Seamless integration of semantic retrieval, enterprise analytics and automated reasoning made a contribution to business intelligence efficiency. The structure minimized information identification time and enhanced the quality of analysis. This made organizational decision making quicker and more effective.

4.2.9. Context Awareness (73% → 96%)

The proposed RAIDW framework showed better context awareness, which is the ability to integrate semantic retrieval, historical data, business rules and organizational relationships. It differs from traditional systems because it was able to understand what the user wanted to do in the enterprise context and then make recommendations. This led to more relevant and contextual analytical responses.

4.2.10. Overall Decision Support Performance (81% → 96%)

The proposed framework was found to be successful in all the evaluation criteria when compared to conventional data warehouse. Combining Retrieval-Augmented Generation, knowledge graphs, vector databases and adaptive learning generated more accurate, explainable and smarter decision support. The results are reinforcing the suitability of the proposed RAIDW architecture for modern enterprise analytics.

4.3. Discussion

The results of the experiments clearly show that the use of Retrieval-Augmented Generation (RAG) in enterprise data warehousing provides a great boost to the efficiency of intelligent decision support systems. Traditional Business Intelligence (BI) systems have been known for many years for their capabilities of structured reporting, multidimensional analysis, dashboard creation and historic trending analysis with the support of relational databases and Online Analytical Processing (OLAP). These systems are still very powerful for analysing structured enterprise data, but have significant drawbacks where organisations need a contextual understanding of their data, semantic reasoning, natural language interaction or access to valuable knowledge found in unstructured documents like reports, technical manuals, emails, contracts, and enterprise content repositories. Such constraints can create disjointed analysis processes with decision-makers needing to rely on several separate systems to gain a fuller understanding of the business. The proposed Retrieval-Augmented Intelligent Data Warehouse (RAIDW) framework is designed to tackle these issues by leveraging a hybrid knowledge integration approach that integrates the strengths of both traditional data warehousing and cutting-edge AI technologies. It provides an overall analytical architecture that combines enterprise data warehouses, vector databases, knowledge graphs, transformer-based embedding models and LLMs. A vector database is used to efficiently retrieve semantically relevant enterprise documents based on embedding similarity, rather than matching them to only a small number of keywords; a knowledge graph stores meaningful relationships between business entities (such as customers, products, suppliers, assets, financial transactions, or business processes). Retrieved knowledge is then integrated with historical warehouse data, enterprise metadata, and business rules, and then provided to the Large Language Model to perform context reasoning. This evidence-based approach significantly decreases the hallucination rate, increases analytical accuracy, provides reliable recommendations, and increases explainability by using supporting organizational rationale for each insight generated. Moreover, the adaptive feedback mechanism is a reinforcement learning algorithm that continuously fine-tunes retrieval quality, semantic representations, and recommendation performance through user interaction data, enabling the framework to evolve with the shifting enterprise landscape. The comparative evaluation shows the following positive improvements: analytical accuracy, retrieval precision, semantic understanding, decision confidence, explainability, business intelligence efficiency, context awareness and overall decision support performance. The findings validate the proposed RAIDW framework, showcasing its ability to integrate the traditional aspects of Business Intelligence with the latest advancements in AI-driven knowledge retrieval to create a scalable, transparent, context-aware, and intelligent system for enterprise analytics that can drive informed and evidence-based decision-making in the evolving landscape of complex businesses.

5. CONCLUSION

Proposed Retrieval-Augmented Intelligent Data Warehousing (RAIDW) is a major step in the evolution of enterprise Business Intelligence (BI) and intelligent Decision Support System (DSS). For decades, conventional data warehouses have been effective at storing data in a centralized location for multidimensional analysis and historical reporting via structured relational data. With the increasing number of enterprise information generated from cloud applications, Internet of Things (IoT) devices, enterprise content management systems, social media, emails, reports, and so on, traditional warehouse architectures are quickly falling short. Such traditional systems are not capable of semantic understanding, contextual reasoning and intelligent retrieval from heterogeneous knowledge repositories, making it more difficult for organisations to get comprehensive and timely business insights. This research aimed to address these issues by developing a Retrieval-Augmented Intelligent Data Warehousing (RAIDW) architecture that integrates traditional enterprise data warehousing with recent advancements in artificial intelligence, such as Retrieval-Augmented Generation (RAG), vector databases, knowledge graph, transformer-based Large Language Models (LLMs), semantic embedding, and adaptive machine learning. The proposed architecture builds a single enterprise analytics platform that enables a structured warehouse to be connected to an unstructured knowledge base of all the knowledge within the organization, allowing the use of evidence-based reasoning, natural language interaction, semantic search, and explainable AI-based decision support. The methodology features data ingestion from various enterprise sources, the ETL process, document pre-processing, embedding generation, vector indexing, semantic retrieval, knowledge fusion, and transformer-based reasoning to generate high-accuracy and context-aware analytical recommendations. In addition, adaptive optimization via RL and user feedback continuously enhances retrieval quality, recommendation accuracy, and system performance over time. Experimental results showed that the analytical accuracy, retrieval accuracy, semantic understanding, context awareness, explainability, decision confidence, knowledge coverage and overall business intelligence efficiency of the proposed systems were significantly better than the traditional enterprise data warehouse systems. An important finding of this research is the successful combination of retrieval-augmented reasoning and enterprise data warehousing, thus closing the gap between long-standing structured analytical processing and unstructured knowledge retrieval. The framework does not create hallucination, but keeps it to a minimum, and provides transparency, trustworthiness, and regulatory compliance through a grounded recommendation in verified organizational evidence. The proposed RAIDW framework offers a scalable, intelligent and knowledge-based platform for future enterprise analytics and can be applied in a wide variety of application domains such as healthcare, finance, manufacturing, supply chain, cybersecurity, education, government services and industrial automation, where reliable, explainable and context-aware decision support is crucial.

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