

Abstract

In today's data-driven world, effective visualization is essential for making sense of complex datasets. Traditional 2D visualizations, while widely used, often fall short in conveying multidimensional insights due to their static and flat nature. This project addresses these limitations by developing a system that transforms textual descriptions of numerical data into dynamic visualizations rendered in Virtual Reality (VR) and Augmented Reality (AR) environments.

The system leverages Large Language Models (LLMs) to convert natural language input into structured tabular data in JSON format. A Retrieval-Augmented Generation (RAG) model is then used to determine the most appropriate visualization type—such as bar charts or line charts—based on the structure and content of the tabular data.

These visualizations are rendered as 3D models in VR and AR. In VR, users can explore the data through basic interactions like zooming, panning, and rotating. In AR, visualizations are presented as floating 3D models, offering a lightweight and portable viewing experience. This immersive approach enhances user understanding, enabling deeper insights and improved pattern recognition compared to traditional methods.

The system demonstrates potential across various domains—including education, healthcare, business analytics, and scientific research—where intuitive and interactive data exploration is vital for informed decision-making.

Key words: Virtual Reality (VR), Augmented Reality (AR), Data Visualization, Text-to-Table Conversion, Large Language Models (LLMs), Retrieval-Augmented Generation (RAG), JSON, Natural Language Processing (NLP), Interactive 3D Models, Immersive Analytics, Visualization Systems, Data Interpretation, Pattern Recognition, Data Science, Information Retrieval, Educational Technology, Business Intelligence, Scientific Visualization.

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Nomenclature

VR	Virtual Reality: A simulated 3D environment that immerses users in a virtual world, allowing interaction with data.
AR	A technology that overlays digital 3D visualizations onto the real-world environment through a camera view, enabling contextual data display without full immersion.
LLM	Large Language Model: A machine learning model designed to process and generate human-like text, used for converting textual data to structured tables.
RAG	Retrieval-Augmented Generation: A model that enhances accuracy by retrieving relevant information to guide visualization selection.
3D Visualization	Three-dimensional representation of data in a VR environment for immersive exploration.
NLP	Natural Language Processing: A field of AI enabling machines to interpret and generate human language.
Data Filtering	The process of selectively viewing subsets of data based on user-defined conditions.
Zooming	Adjusting the scale of a visualization to either zoom in on a specific area or get an overview of the data.
Scale Adjustments	Modifying the dimensions or proportions of a visualization to highlight specific data aspects.
User Interaction	The capability for users to manipulate and engage with visualized data, such as filtering, rotating, or adjusting the scale.
Data Representation	The method by which data is presented visually or in a structured format, such as tables or charts.
Machine Learning (ML)	A subset of AI that allows systems to learn patterns from data and

improve over time.

Data Science	A field that uses scientific methods, algorithms, and systems to extract knowledge from structured and unstructured data.
Visualization Design	The practice of creating clear, effective visual representations of data that are easy to interpret.
Visualization Systems	Platforms that generate and display data visualizations for analysis, from simple charts to complex 3D models.
Information Retrieval	The process of obtaining relevant data from large datasets to determine the best visualization type.
Immersive Visualization	A method that allows users to interact with and explore data in a 3D, engaging virtual environment.
Interactive 3D Models	Visual representations of data in three dimensions, allowing users to manipulate and gain insights.