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AI Agent for Data Visualization

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Abstract - In the age of big data, the ability to interpret, analyse, and visualize vast amounts of information has become increasingly essential for both organizations and individuals. Data visualization plays a crucial role in enabling users to uncover trends, patterns, and insights that are otherwise hidden in raw numerical or textual data. Traditional data visualization tools, such as Microsoft Excel, Tableau, or Power BI, although powerful, often require a certain level of expertise in data handling, chart selection, and domain knowledge to produce meaningful visual representations. As the volume and complexity of data continue to increase, the need for intelligent systems that can automate and simplify the process of data visualization becomes more pressing.

1.INTRODUCTION

In today's data-driven world, the ability to interpret and communicate data effectively is essential. Visualization tools like Tableau, Power BI, and Excel help translate raw data into understandable formats. However, these tools often require manual setup, technical knowledge, or programming skills. This creates a barrier for non-experts or users who want quick insights without deep involvement in the visualization process. To address this, we propose an AI agent that acts as a smart assistant for data visualization. This agent can process natural language inputs—such as "Show me the sales trend for the last six months"—and automatically identify the appropriate data fields, analyze the data, and generate the most relevant visual output. It uses techniques from natural language processing, data analysis, and visualization libraries like Matplotlib, D3.js, or Plotly. The goal is to make data visualization more accessible, faster, and more user-friendly, enabling users from all backgrounds to explore and understand data with ease.

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LITERATURE SURVEY :

1) Siva Karthik Devineni

Abstract: Purpose: The purpose of this study is to explore how artificial intelligence (AI) becomes a part of data visualization. Thus, data from complex datasets are transformed into dynamic, interactive, and personalized visual experiences that will help in deeper insights and actionable knowledge. The research is supposed to design a holistic system and rules for using AI to make data visualization more effective and super interactive for the users. Methodology: The methodology involves the in-depth examination of artificial intelligence-based data visualization tools and platforms by using case studies. The study analyses the impact of AI technologies such as machine learning, natural language processing, and augmented and virtual reality on the scalability, interactivity, and personalization of data visualizations. The sentence also talks about the analysis of the moral factors that are part of the process of introducing AI in data visualization. Introduction: DATA VSULIZTION is transforming data from logical and raw formats into graphical and pictorial depictions like charts, graphs and maps, making things easier to digest, analyze and make educated decisions. Such a phenomenon makes it easier for analyzers to look for patterns, trends, and outliers within the tons of data. With graph to display data, the data interconnectedness becomes clearer and user-friendly for drawing insights and communicating findings [1]. Data visualization is a widely used tool in business, health, science, and engineering analysis, allowing the representatives to perceive information essentially by glancing over the diagrams and making relevant action decisions based on figures [2]. First, the critical role of data visualization in data perception improvement is that it helps summarize enormous volumes of data and make it simpler and more understandable. Analyzing and reasoning with data is a vital skill for the users, and visualizing data is a powerful tool for this purpose. It helps simplify and visualize the intellectual task so that most people can quickly grasp the presented information [3]. SEACET, DEPT OF CSE 2024-25 3 AI AGENT FOR DATA VISUALIZATION PROJECT PHASE I 2) Rania Saber, Anna Fariha Abstract: This formative study investigates the impact of data quality on AI assisted data visualizations, focusing on how uncleaned datasets influence the outcomes of these tools. By generating visualizations from datasets with inherent quality issues, the research aims to identify and categorize the specific visualization problems that arise. The study further explores potential methods and tools to address these visualization challenges efficiently and effectively. Although tool development has not yet been undertaken, the findings emphasize enhancing AI visualization tools to handle flawed data better. This research underscores the critical need for more robust, user friendly solutions that facilitate quicker and easier correction of data and

visualization errors, thereby improving the overall reliability and usability of AI-assisted data visualization processes. Introduction: With the emergence of AI tools such as ChatGPT in today's data driven world, the ability to visualize data effectively is crucial for extracting actionable insights from large and complex datasets. AI assisted data visualization tools have gained prominence due to their capability to automate and enhance the visualization process, making it accessible to a wider audience. However, the effectiveness of these tools is heavily dependent on the quality of the underlying data. Poor data quality, characterized by errors, inconsistencies, and missing values, can lead to inaccurate or misleading visualizations, ultimately compromising decision-making processes. Despite the growing reliance on AI-driven visualization tools, there is a significant gap in understanding how these tools handle uncleaned datasets. This study addresses this gap by exploring the specific challenges and limitations of AI-assisted visualizations when faced with data quality issues. By generating visualizations using uncleaned datasets, we aim to identify and categorize common visualization problems, providing valuable insights into the weaknesses of current AI tools in processing flawed data. The primary objective of this research is to investigate methods and tools that could potentially address these visualization issues quickly and effectively. While this study focuses on identifying the problems and proposing potential solutions, it does not yet involve the development of new tools. Instead, it lays the foundation for future work aimed at enhancing the efficiency and usability of AI assisted data visualization tools. SEACET, DEPT OF CSE 2024-25 4 AI AGENT FOR DATA VISUALIZATION PROJECT PHASE I 3) Wenyi Ouyang Abstract: The advent of the big data era has made data visualization a crucial tool for enhancing the efficiency and insights of data analysis. This theoretical research delves into the current applications and potential future trends of data visualization in big data analysis. The article first systematically reviews the theoretical foundations and technological evolution of data visualization, and thoroughly analyzes the challenges faced by visualization in the big data environment, such as massive data processing, real-time visualization requirements, and multi-dimensional data display. Through extensive literature research, it explores innovative application cases and theoretical models of data visualization in multiple fields including business intelligence, scientific research, and public decision-making. The study reveals that interactive visualization, real time visualization, and immersive visualization technologies may become the main directions for future development and analyzes the potential of these technologies in enhancing user experience and data comprehension. The paper also delves into the theoretical potential of artificial intelligence technology in enhancing data visualization capabilities, such as automated chart generation, intelligent recommendation of visualization schemes, and adaptive visualization interfaces. The research also focuses on the role of data visualization in promoting interdisciplinary collaboration and data democratization. Finally, the paper proposes theoretical suggestions for promoting data visualization technology innovation and application popularization, including strengthening visualization literacy education, developing standardized visualization frameworks, and promoting open-source sharing of visualization tools. This study provides a comprehensive theoretical perspective for understanding the importance of data visualization in the big data era and its future development directions. Introduction : With the rapid development of information technology and the significant enhancement of data collection capabilities, human society is entering an unprecedented era of big data. Massive, diverse, and high-velocity data streams are reshaping the operational modes and decision-making methods across various industries [1]. However, data itself does not equate to insight; how to extract valuable information from complex data has become a key issue that urgently needs to be addressed. In this context, data visualization, as a bridge connecting raw data and human cognition, is playing an increasingly important role. Data visualization effectively reveals hidden patterns, trends, and associations in data by transforming abstract data into intuitive graphical expressions, thereby enhancing human cognitive SEACET, DEPT OF CSE 2024-25 5 AI AGENT FOR DATA VISUALIZATION PROJECT PHASE I abilities and decision-making efficiency [2]. In recent years, with the continuous advancement of big data analysis technologies, data visualization also faces new opportunities and challenges. Traditional static charts and simple interactive visualizations can no longer cope with massive, high-dimensional, and dynamic big data environments, prompting researchers to continuously explore new visualization theories and technical methods [3]. Meanwhile, the development of emerging technologies such as artificial intelligence and virtual reality has provided a broad space for innovation in data visualization. In fields such as business intelligence, scientific research, and public decision-making, data visualization is playing an increasingly important role, driving data-driven decision-making models and innovative practices. However, how to achieve efficient, accurate, and insightful data visualization in the big data environment still faces many theoretical and technical challenges. Based on this, this study aims to systematically review the current applications of data visualization in big data analysis, discuss possible future development trends, and provide references and insights for promoting the innovative development of data visualization theory and practice. This paper is structured as follows: Section 2 explores the evolution of big data visualization techniques; Section 3 analyzes the applications of big data visualization in business intelligence, scientific research, and public policy; Section 4 looks at future trends; and finally, Section 5 concludes the paper. 4) Chenglong Wang, Bongshin Lee Abstract : Data analysts often need to iterate between data transformations and chart designs to create rich visualizations for exploratory data analysis. Although many AI-powered systems have been introduced to reduce the effort of visualization authoring, existing systems are not well suited for iterative authoring. They typically require analysts to provide, in a single turn, a text-only prompt that fully describe a complex visualization. We introduce Data Formulator 2 (Df2 for short), an AI-powered visualization system designed to overcome this limitation. Df2 blends graphical user interfaces and natural language inputs to enable users to convey their intent more effectively, while delegating data transformation to AI. Furthermore, to support efficient iteration, Df2 lets users navigate their iteration history and reuse previous designs, eliminating the need to start from scratch each time. A user study with eight participants demonstrated that Df2 allowed participants to develop their own iteration styles to complete challenging data exploration sessions. Introduction :In data exploration [47], even when starting with an initial idea, analysts often need to go back and forth exploring a variety of charts before reaching their goals. Throughout this iterative process, analysts often discover insights that lead SEACET, DEPT OF CSE 2024-25 6 AI AGENT FOR DATA VISUALIZATION PROJECT PHASE I them into new directions. However, analysts need to tackle numerous execution challenges: in addition to varying chart specifications (as many current tools facilitate), they need to perform and manage different data transformations to support the desired visualization designs.

For example, when exploring renewable energy trends, an analyst may find that similar trends across countries make a simple line chart (Figure 1) too dense for detailed comparisons. This observation prompts the analyst to explore the renewable percentage trends of the top 5 CO2 emitters and how the rankings of these countries have changed over time. To execute the plan, the analyst needs different data transformations: the first requires filtering the data based on each country's total CO2 emissions, and the second requires partitioning the data by year to compute each country's ranking for that year. Because data transformation can be difficult to learn and execute, many AI-powered tools have been developed [2, 10, 31, 36, 57, 58]. These tools allow users to describe their goals using natural language and leverage AI models' code generation capabilities [1, 5] to streamline data transformation and chart creation. Despite their success, current tools do not perform well in the iterative visualization authoring context. Most of them require analysts to provide, in a single turn, a text-only prompt that fully describes the complex visualization task to be performed, which is usually unrealistic for both users and models.

Table -1: Ai – Agent Development process

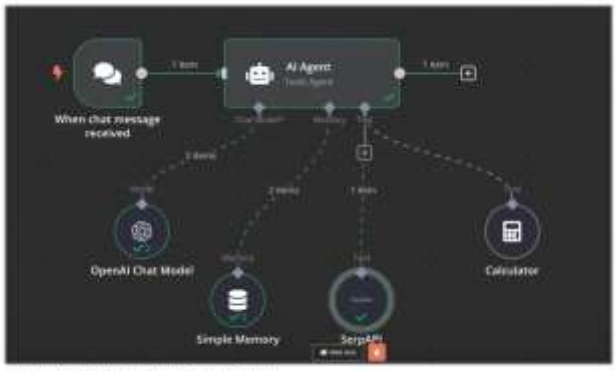

Figure 01. AI-Agent development process.

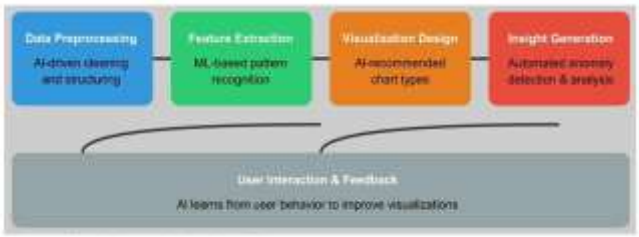

Figure 02. AI-enhanced data visualization process.

PROBLEM STATEMENT

The primary problem this research addresses is the complexity involved in traditional data visualization processes. Even with graphical interfaces, users are often required to:

1. Preprocess and Clean Data Manually
2. Select Appropriate Visualization Types Based on Data Characteristics
3. Understand the Principles of Data Encoding
4. Use Formulas or Scripting Languages (e.g., DAX, SQL) for Advanced Features

EXISTING SYSTEMS

1. Introduction

Data visualization plays a pivotal role in data analysis, business intelligence, and decision-making processes. With increasing data complexity, AI agents are being integrated into visualization tools to assist users in understanding data effectively. These AI-driven systems can automate chart generation, recommend appropriate visual formats, interpret natural language queries, and even explain trends and anomalies. This section explores the existing systems, platforms, and technologies that employ AI to enhance data visualization. It highlights their architectures, capabilities, strengths, and limitations. We categorize these systems into:

• AI-powered BI Tools
• Natural Language Interfaces for Visualization
• Auto-Visualization Systems
• Open-source AI frameworks.

1 AI-Powered Business Intelligence Tools.
2. Natural Language Interfaces for Data Visualization.
3. Automated Visualization and Insight Generation Systems.
4. Chartify.
5. Open-Source & Academic Projects.

PROPOSED SYSTEM

The proposed system is an intelligent AI agent that transforms complex datasets into simple, understandable, and visually appealing outputs. It is designed to assist users— especially non-technical ones—by automating and simplifying the entire data analysis and visualization process. The system focuses on usability, clarity, and flexibility.

1. Simplifies Data:

One of the primary functions of the AI agent is data simplification. Raw datasets are often messy, incomplete, or difficult to interpret. This system includes AI-driven preprocessing modules that: • Clean the data by removing errors, duplicates, or irrelevant entries. • Organize data by grouping similar records, categorizing variables, and identifying relationships. • Reduce complexity by selecting only key features or metrics based on user goals. •

Summarize large datasets into concise, digestible formats such as summaries, averages, totals, or percentages.

2. Provides Simple Diagrams:
The AI agent automatically generates visualizations that are simple, clean, and appropriate for the type of data. It uses smart chart selection algorithms to choose the best type of diagram (e.g., bar chart, pie chart, line graph) based on:
• Data type (categorical, numerical, time series)
• User query (e.g., comparison, distribution, trend)
• Number of variables involved These diagrams are: • Easy to read with clear labels, legends, and color schemes.

3. Provides Simple Insights :
Beyond creating diagrams, the AI agent delivers natural-language explanations of the data. These insights are automatically generated using data analysis and natural language generation (NLG) techniques. The system identifies: • Trends (e.g., "Sales increased steadily from January to June") • Outliers (e.g., "Unusually high traffic was recorded in March") • Comparisons (e.g., "Product A performed 20% better than Product B") • Correlations or relationships between variables These insights are presented in plain English, without statistical jargon, making it easy for non-experts to understand.

4. Adds Missing Data from the Web :
When users work with incomplete datasets, the AI agent can augment the data by automatically searching for and filling in missing information using trusted web sources or APIs. This process involves:
• Identifying missing fields or gaps in the dataset
• Searching reliable public data sources (e.g., government data portals, open APIs, financial websites)
• Cross-checking and validating the data
• Adding or suggesting the missing data to the user.

METHODOLOGY

Methodology of AI-Based Data Visualization System The methodology outlines how the AI agent processes raw data and transforms it into simplified, insightful, and user-friendly visual outputs. The system consists of several integrated modules that work together in a pipeline to automate data preparation, visualization, and communication. Overview of Methodology The methodology follows these key stages:
1. Data Ingestion.
2. Data Preprocessing and Simplification.
3. Data Augmentation (Fetching Missing Data from Web).
4. Natural Language Processing (for Understanding and Simplifying Language).
5. Visualization Generation.
6. Insight Extraction and Explanation.
7. Output Formatting and Customization.

System Workflow Diagram (Summary) :

[User Input]
↓
[Data Ingestion]
↓
[Data Cleaning & Simplification]
↓
[Web Augmentation (if needed)]
↓
[NLP Interpretation / Simplification]
↓
[Chart Generation Engine]
↓
[Insight Detection & Natural Language Summary]
↓
[User-Selected Output Format]
↓
[Final Visual Report / Export]

SOFTWARE AND TOOLS USED

Here is a detailed explanation of how you can use n8n software in combination with HTML, CSS, and JavaScript to build a complete AI Agent for Data Visualization with both back-end automation and front-end interface.

Overview of Technologies Used
n8n (Back-end automation + AI agent logic)

n8n (pronounced “n-eight-n”) is a workflow automation tool that allows you to connect APIs, automate data processing, and integrate services without writing full scale back-end code. • Use in this project: Handle AI agent logic, API calls, data fetching, AI model integration, and background automation.

HTML, CSS, JavaScript (Front-end website)
These standard web technologies are used to build the user interface (UI) for interacting with the AI agent.
• Use in this project: Display UI where users can upload data, select visualization types, see charts and receive natural-language insights.

Role of n8n in AI Agent for Data Visualization
n8n plays the core automation and AI logic role in the proposed system. It acts like the brain of the AI agent by handling:

1. Data Ingestion and Cleaning.
2. Calling AI APIs for Analysis and Insights.
3. Visualization Generation.
4. Web Data Fetching (Data Augmentation)

3. CONCLUSIONS

The development of an AI-based Data Visualization Agent represents a major advancement in how users interact with and understand complex data. By integrating artificial intelligence with automation workflows and intuitive front-end design, the system provides a user-friendly, intelligent, and adaptable platform for data analysis and visualization. This project successfully addresses several critical challenges that non-technical and technical users often face in traditional data analysis: • It simplifies raw data into meaningful and readable formats. • It generates visual diagrams automatically, eliminating the need for manual charting. • It translates complex insights and jargon into plain language, making data accessible to all. • It fills in missing or incomplete data by leveraging web-based APIs and resources. • It offers flexible output formats, allowing users to export results as reports, charts, tables, or text.

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REFERENCES

Artificial Intelligence / NLP Models
• OpenAI GPT (ChatGPT, GPT-3.5, GPT-4)
https://openai.com/gpt

• Hugging Face Transformers (Text summarization, simplification) https://huggingface.co/models

• Google T5 (Text-To-Text Transfer Transformer) https://arxiv.org/abs/1910.10683

Automation Platform

• n8n – Workflow Automation Tool
https://n8n.io/
Docs: https://docs.n8n.io/

Functions used:

o HTTP Requests.
o Webhooks.
o JavaScript Code nodes.
o Integration with OpenAI and other APIs.

Data Visualization Libraries:

• Chart.js – Simple JavaScript charting library
https://www.chartjs.org/

• Plotly.js – Interactive plotting library
https://plotly.com/javascript/

• D3.js – Data-Driven Documents (advanced visuals)
https://d3js.org/

Web Data & APIs (For Data Augmentation)
• OpenWeatherMap API – Weather data https://openweathermap.org/api

• World Bank API – Economic and demographic data https://datahelpdesk.worldbank.org/

• REST Countries API – Country details https://restcountries.com/

• Rapid API – API marketplace https://rapidapi.com/

Web Development Technologies

• HTML5 – Page structure
https://developer.mozilla.org/en-US/docs/Web/HTML

• CSS3 / Tailwind CSS – Styling https://tailwindcss.com/

•JavaScript – Interactive functionality https://developer.mozilla.org/en-US/docs/Web/JavaScript

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