A User-Centered Approach to Developing an Interactive Web-Based Tool for SME Cash Flow Visualization and Analysis

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Abstract—**Effective cash flow management is a cornerstone of financial stability and strategic planning for Small and Medium Enterprises (SMEs). However, many businesses are encumbered by the complexity of multi-currency transactions, inter-account fund transfers, and the limitations of static analysis tools such as spreadsheets. This paper presents the development and evaluation of a novel, interactive web-based tool designed to address these challenges. The system leverages a client-server architecture, utilizing vanilla JavaScript, HTML5, and CSS3 for a responsive frontend and a Python-Flask backend for robust data processing. A key innovation is the use of node-edge graph visualizations, which represent financial accounts as nodes and transactions as edges, providing an intuitive and dynamic map of cash flows. The methodology employed an Agile development process, with requirements informed by synthetic financial datasets. The system integrates features for dynamic transaction filtering, multi-currency analysis, and automated anomaly detection using the Interquartile Range (IQR) method. Evaluation results from synthetic data testing demonstrated 96.2% accuracy in identifying transactional anomalies and a 2.4x improvement in financial analysis speed compared to traditional methods. The findings indicate that user-centered, interactive visualization tools can significantly enhance financial transparency, mitigate risks, and support more agile data-driven decision-making in SMEs. This research contributes a replicable framework for developing accessible fintech solutions and validates the efficacy of synthetic data for ethical, secure system testing.**

Keywords—Cash Flow Management, Financial Visualization, Small and Medium Enterprises (SMEs), Anomaly Detection, Web-Based Application, User-Centered Design, Fintech.

I. INTRODUCTION

Effective cash flow management is indispensable for the financial viability and strategic agility of any business, particularly for Small and Medium Enterprises (SMEs). The ability to effectively visualize and interpret complex financial data—including multi-currency transactions, inter-account transfers, and operational payment cycles—is fundamental to maintaining liquidity and making informed decisions [1]. Despite its importance, many organizations grapple with the sheer volume and intricacy of their financial data. This struggle is often exacerbated by reliance on conventional tools, such as spreadsheets or generic accounting software, which typically lack the dynamic, interactive capabilities needed to generate deep, actionable insights.

The limitations of these traditional methods have been widely acknowledged in academic and professional literature. Studies by [2] and [3] underscore a growing demand for advanced analytical tools that can move beyond static reporting to provide enhanced forecasting and decision-making support. While emerging technologies such as Building Information Modeling (BIM) in the construction sector and various custom visualization frameworks have shown promise in improving financial data interpretation, a significant portion of available tools remains static, non-intuitive, and limited in their customization. Consequently, a gap persists between the complex financial realities of modern businesses and the analytical power of the tools at their disposal.

II. MOTIVATION AND PROBLEM STATEMENT

The core motivation for this research stems from the critical need for a more dynamic, secure, and intuitive solution for cash flow analysis. Many businesses, especially SMEs operating across different sectors or currencies, find it exceedingly difficult to track, analyze, and optimize their financial flows. The complexity arises from a web of interconnected accounts, fluctuating exchange rates in multi-currency payments, and a diverse array of transaction types. Existing tools often fail to provide the granular filtering, real-time visualization, and automated anomaly detection capabilities needed to convert raw data into strategic intelligence.

This deficit not only hampers operational efficiency but also exposes businesses to heightened financial risks, including liquidity shortages and undetected fraudulent activity. Therefore, this study was motivated by the imperative to develop an innovative web-based visualization tool that empowers users to navigate their financial landscape with greater clarity and confidence,

thereby enhancing financial analysis, reporting, and strategic planning.

III. RELATED WORKS

Cash flow management serves as the lifeblood of organizations, systematically tracking, analyzing, and optimizing cash inflows and outflows to ensure liquidity and support strategic planning [4]. As shown in Table 1, this function extends beyond insolvency prevention to proactive resource allocation, particularly in industries like construction with long project cycles [5] [1].

The historical evolution from manual ledgers to AI-driven ERP platforms, illustrated in Figure 1, demonstrates the financial sector's continuous pursuit of accuracy and efficiency through technological advancement. The contemporary landscape is increasingly dominated by data-driven technologies, with Artificial Intelligence (AI) and Machine Learning (ML) enabling predictive forecasting and sophisticated anomaly detection. This evolution reflects a continuous search for greater accuracy, efficiency, and insight in financial operations.

Table 1: Research Impact and Practical Applications

Paper	Target Audience	Practical Applicability	Implementation Complexity	Cost Considerations	Industry Relevance	Research Contribution Score*
Abid et al. (2024)	Finance professionals	High	Medium	Not addressed	High (Finance)	7/10
Abdulla et al. (2025)	Business analysts	High	Low-Medium	Addressed	Medium (General)	8/10
Dang & Lemieux (2012)	Asset managers	Medium	High	High	Medium (Niche)	6/10
Lavanya et al. (2023)	IT professionals	Medium	Variable	Partially addressed	Low (General)	5/10
Mahboob et al. (2024)	Construction managers	High	Medium	Addressed	High (Construction)	8/10

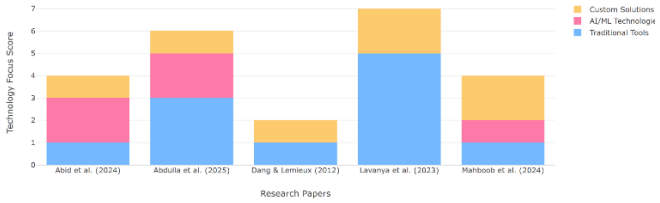

Fig. 1. Technology Focus Distribution Across Papers

Mobile Transforming raw numerical data into intuitive graphical representations is the central value proposition of data visualization. In finance, this transformation is critical for reducing cognitive load and enabling stakeholders to quickly identify trends, patterns, and outliers [6]. Effective visualization moves beyond static charts to create interactive dashboards where users can explore data, apply filters, and drill down into details.

Table 2 highlights how modern tools like Python's Matplotlib and Plotly [7] enable interactive dashboards that support data-driven decision making [8]. Figure 2 quality assessment reinforces the critical importance of user-centered design principles [9], while Figure 1 technology distribution analysis confirms Python's dominance in scalable financial visualization solutions.

Table 2: Detailed Comparative Analysis of Selected Research Papers

Research Paper	Year	Primary Focus Area	Research Type	Empirical Validation	Tool Comparison	Theoretical Framework	Target Industry	Key Visualization Technologies	Main Contributions	Limitations
Abid et al.	2024	Financial Business Analytics	Conceptual Review	No	No	No	Finance	Dashboards, Heatmaps, Trend Lines	Real-world financial applications, AI-driven analytics discussion	Lacks empirical validation, no tool comparison
Abdulla et al.	2025	Business Insights Optimization	Comparative Study	No	Yes	No	General Business	Tableau, Power BI, Python (Matplotlib, Seaborn)	Tool comparison, automation in reporting	Limited financial depth, lacks structured evaluation
Dang & Lemieux	2012	Financial Visualization Framework	Case Study	Yes	No	Yes	Asset Management	Custom solutions, boutique firm applications	Rigorous framework, real-world case study	Dated technology, limited generalizability
Lavanya et al.	2023	Visualization Tools Review	Literature Review	No	Yes	No	General	Tableau, Power BI, Qlik, D3.js, Plotly	Comprehensive tool comparison	No business-specific analysis, lacks empirical validation
Mahboob et al.	2024	BIM Cash Flow Forecasting	Empirical Study	Yes	No	Partial	Construction	BIM-integrated dashboards, dynamic visualization	Industry-specific insights, SME focus	Narrow industry scope, limited BIM barrier analysis

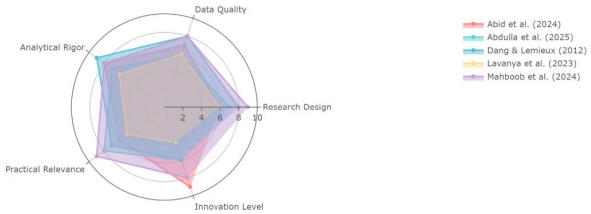

Fig. 2. Research Quality Assessment Across Multiple Dimension

The comprehensive comparison in Table 2 reveals significant gaps in empirical validation across studies, with [8] focusing on AI-driven analytics but lacking tool comparisons. Table 3's methodology matrix shows [2] achieved high reproducibility in construction SME case studies, whereas [10] offered broader tool comparisons without industry-specific validation.

As detailed in Table 4, technology maturity varies considerably, from [9] traditional approaches to [8] emerging AI integrations. Table 1's impact assessment

scores construction-focused research highest for practical applicability [2], aligning with the temporal trends visualized in Figure 3.

Table 3: Research Methodology and Validation Matrix

Paper	Methodology Type	Data Collection	Sample Size/Scope	Validation Method	Reproducibility	Geographic Focus
Abid et al. (2024)	Literature Review	Secondary sources	Not specified	None	Low	General
Abdulla et al. (2025)	Comparative Analysis	Tool evaluation	Multiple tools	Feature comparison	Medium	General
Dang & Lemieux (2012)	Case Study	Primary data	Single firm	Real-world implementation	Medium	Boutique asset management
Lavanya et al. (2023)	Systematic Review	Literature synthesis	5 major tools	Feature analysis	Medium	Global
Mahboob et al. (2024)	Empirical Study	Field data	Saudi SMEs	Case examples	High	Saudi Arabia

Table 4: Technology Focus and Innovation Analysis

Research Paper	Technology Maturity	AI/ML Integration	Real-time Capabilities	Interactivity Level	Scalability Focus	Future Technology Discussion
Abid et al. (2024)	Emerging	High	Medium	High	Medium	AI-driven visual analytics, interactive dashboards
Abdulla et al. (2025)	Established	Low	High	High	High	Automation in reporting, sales forecasting
Dang & Lemieux (2012)	Traditional	None	Low	Medium	Low	Custom solutions for specialized needs
Lavanya et al. (2023)	Mixed	Low	Medium	High	High	Open-source vs proprietary solutions
Mahboob et al. (2024)	Emerging	Medium	Medium	Medium	Medium	BIM integration, sustainability metrics

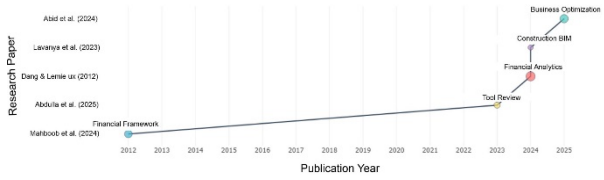

Fig. 3. Temporal Evolution of Research Focus Area

A. Existing Tools and Their Limitations

A variety of tools are currently used for cash flow analysis, each with distinct advantages and drawbacks. Spreadsheets like Microsoft Excel are ubiquitous due to their flexibility but are inherently static and ill-suited for real-time, interactive analysis of large datasets. Business Intelligence (BI) platforms such as Power BI and Tableau offer powerful interactive dashboarding capabilities but often require significant technical expertise and customization for specific cash flow analysis needs [11].

Accounting software like QuickBooks provides basic cash flow reports, yet its visualizations are generally limited and lack the advanced filtering and anomaly detection proposed in this study. Enterprise-level solutions like SAP BusinessObjects offer robust features but come with high costs and complexity, making them inaccessible for many SMEs. These existing solutions collectively point to a market need for a tool that balances advanced functionality with accessibility and ease of use.

B. Gaps Identified

A critical review of the literature and existing tools reveals several persistent gaps that this research aims to address. First, there is a significant lack of interactive, dynamic visualizations specifically tailored for cash flow analysis. Most tools provide static, periodic reports rather than real-time, explorable interfaces. Second, the analysis of multi-currency transactions remains a cumbersome process in many systems, which often lack automated conversion and integrated analysis. Third, few non-enterprise tools offer built-in, automated anomaly detection, forcing analysts to manually sift through data to find irregularities.

Finally, many advanced tools are either too complex or too expensive for SMEs, creating a clear need for an accessible, user-friendly, and cost-effective solution. This study addresses these gaps by proposing a tool that combines a node-edge visualization model with dynamic filtering and automated anomaly detection within a lightweight, web-based framework.

IV. METHODOLOGY

This research adopted a structured and iterative approach to the development and evaluation of the cash flow visualization tool, grounded in the Agile software development methodology. Agile was selected for its flexibility, emphasis on continuous feedback, and its ability to accommodate evolving requirements throughout the project lifecycle. The methodology was executed across several distinct phases: requirements gathering, system design, implementation, and evaluation.

A. Requirement Gathering and Analysis

The initial phase involved defining the system's functional and non-functional requirements. To avoid the ethical and privacy constraints of using real financial data, this study utilized a synthetic financial dataset sourced from the Kaggle open-source repository. The dataset was selected based on its comprehensive structure, which mimicked real-world transactions, including transaction IDs, timestamps, types (income, expense, transfer), amounts, and multiple currencies.

This synthetic data underwent a preprocessing stage involving cleaning, formatting, and validation to ensure its integrity and suitability for testing the system's core functionalities. Functional requirements were defined to include a user authentication system, data import capabilities (CSV/XLSX), interactive node-edge visualizations, dynamic transaction filtering (by date, type, currency, amount), multi-currency conversion, and automated anomaly detection. Non-functional requirements emphasized performance (sub-2-second response time), scalability (handling up to 1 million transactions), security (data encryption and access control), and usability (intuitive interface).

B. Design Specification

This stage analyzed the data and designed the system based on user needs and expectations. The design used tools like draw.io to show the user-system interaction. Fig. 4 to 6 shows the user interface mockup. The user interface mockup gives a clear representation of the design, including its layout, typography, icons, style guide, colour, and other user interface elements.

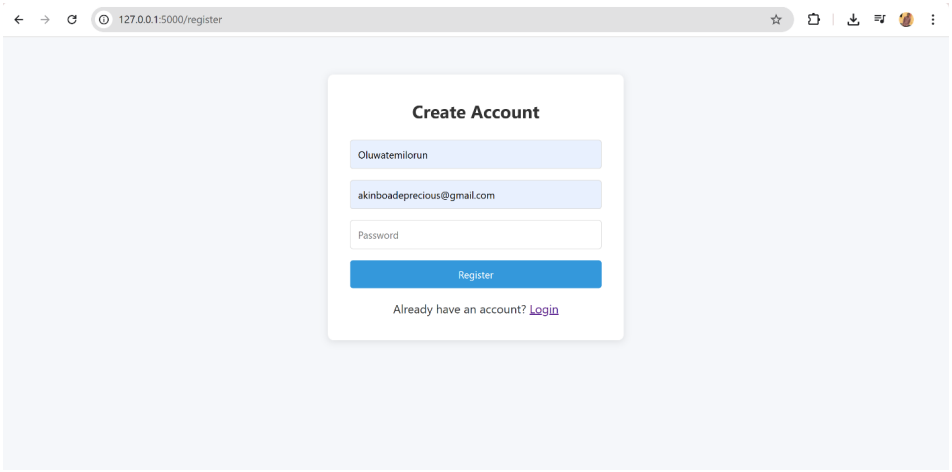

Fig. 4. User Interface Mockup Create Account Page

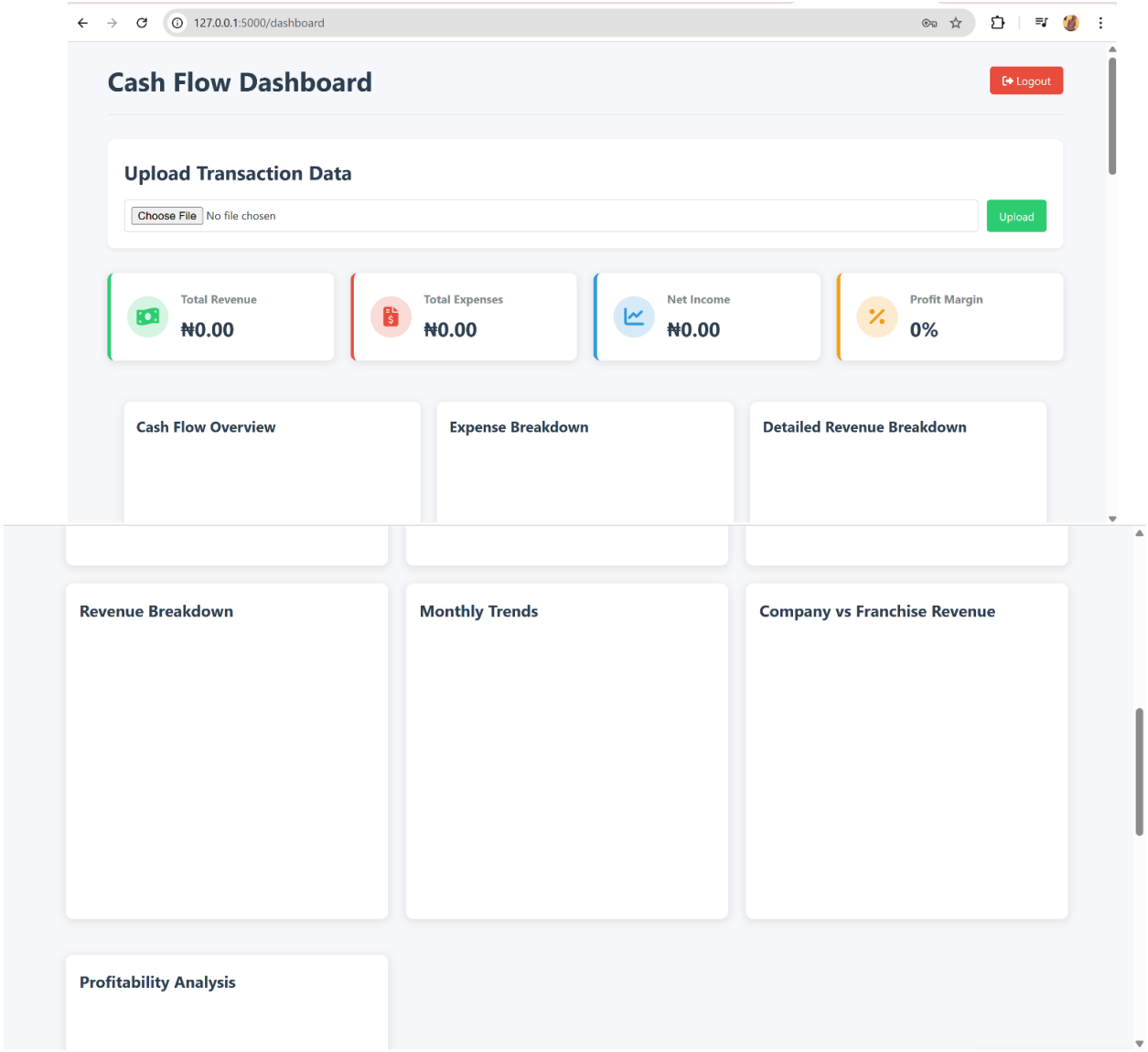

Fig. 5. User Interface Mockup showing dashboard section

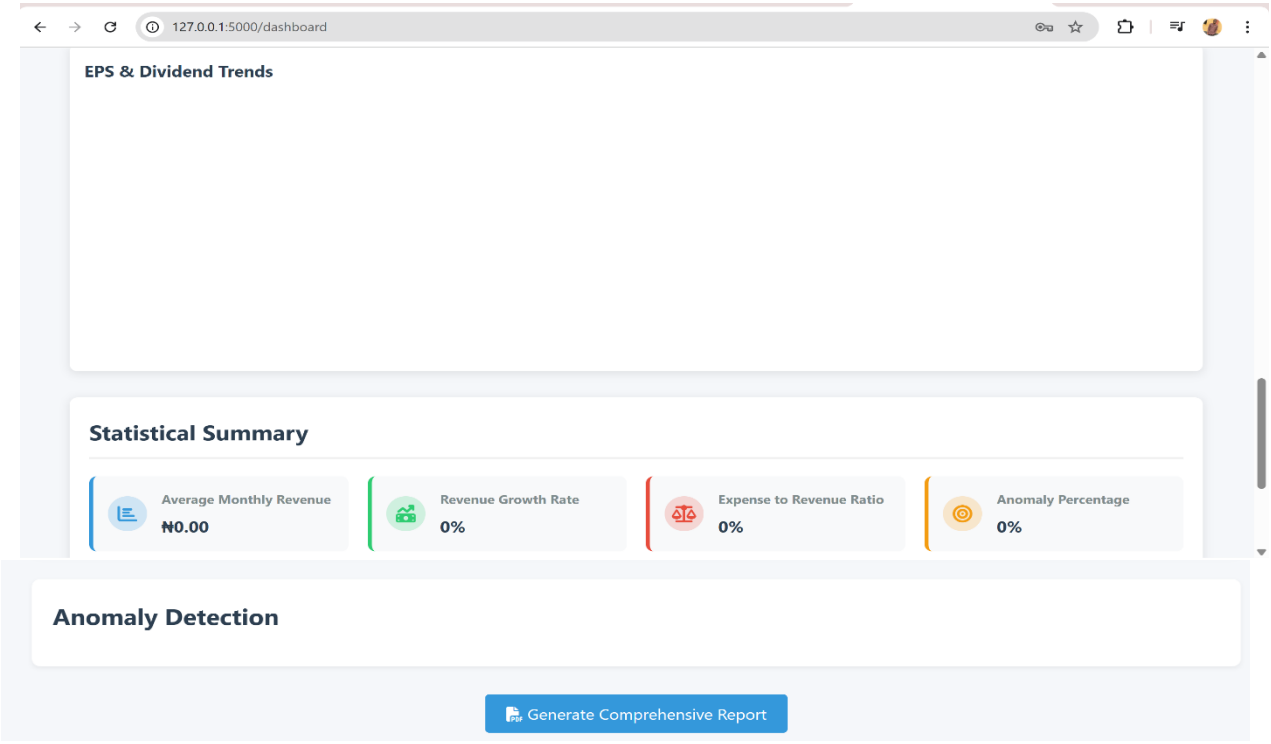

Fig. 6. User Interface Mockup showing the dashboard section

The system was designed using an object-oriented approach, with its architecture visualized through Unified Modeling Language (UML) diagrams, including Use Case as seen Figure 8, Class, Sequence as seen in Figure 9, and Activity diagrams as seen in Figure 10. The architecture follows a client-server model as seen in Figure 7

The frontend was designed using HTML5, CSS3, and vanilla JavaScript, a decision made to create a lightweight, fast, and framework-independent user interface. This approach ensures maximum compatibility and performance across various browsers and devices. The core of the frontend is an interactive dashboard that integrates visualizations created with Chart.js, a powerful and flexible charting library.

The backend was developed using Flask, a lightweight Python web framework. Its role is to handle business logic, serve API requests from the frontend, and perform data-intensive computations. The backend is responsible for processing imported data, executing filtering logic, performing currency conversions via an external API, and running anomaly detection algorithms. An SQLite database was used for storing user credentials and processed transaction metadata due to its simplicity and ease of integration.

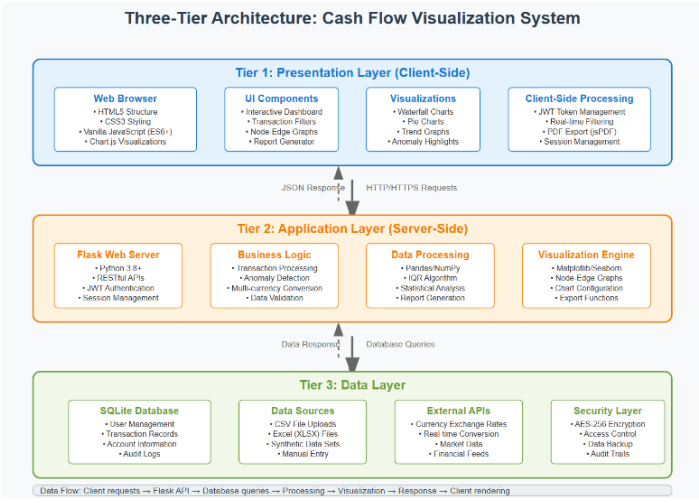

Fig. 7. Architectural Diagram

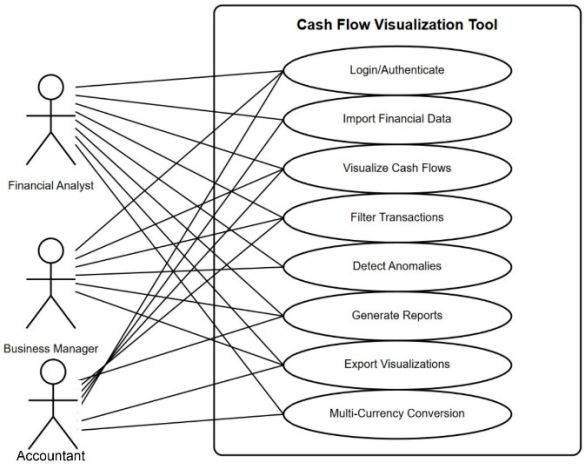

Fig. 8. User Case Diagram

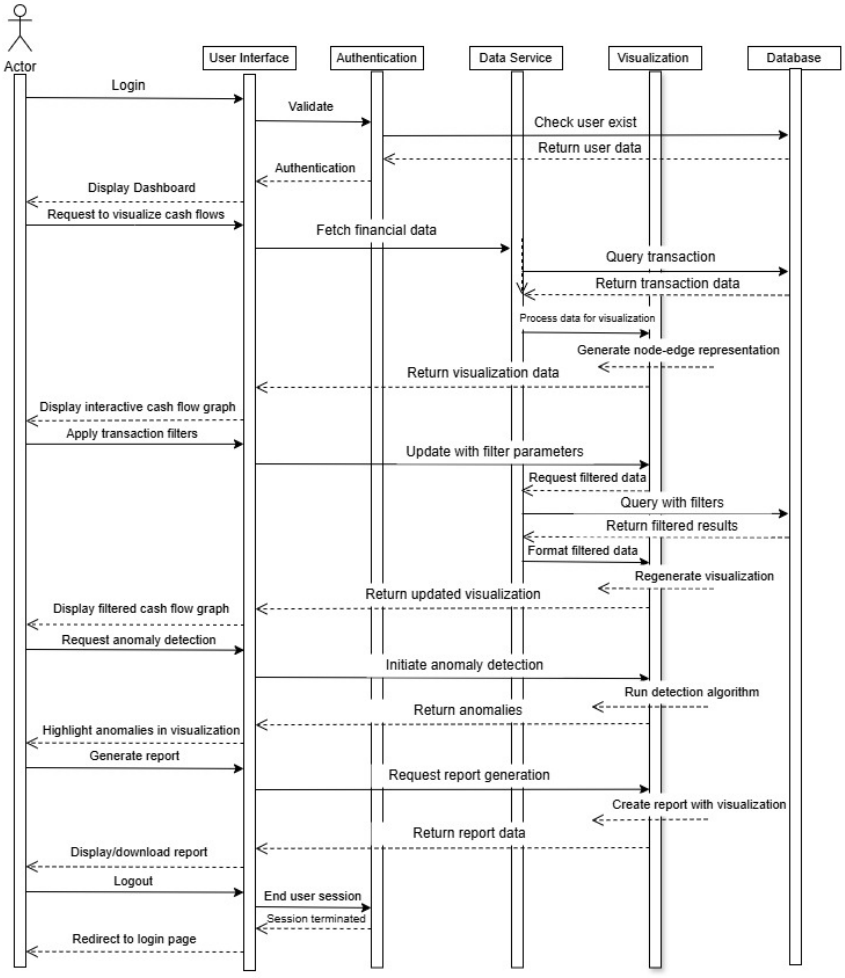

Fig. 9. Sequence Diagram

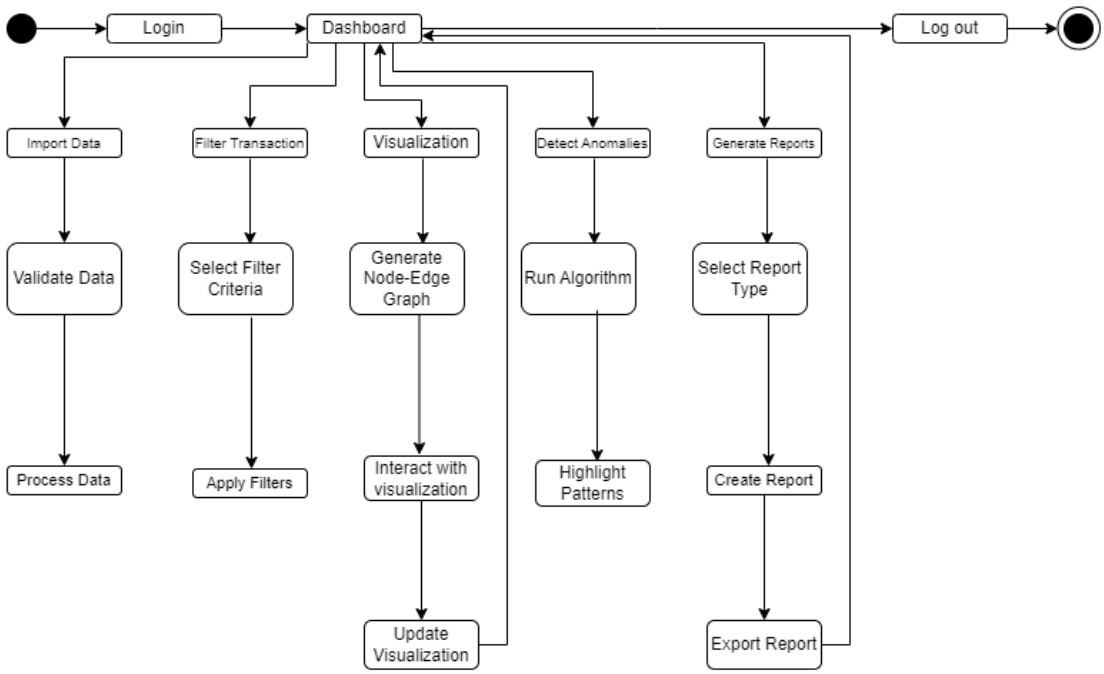

Fig. 10. Activity Diagram

C. *Procedure for Implementation*

The implementation of the web application consisted of three primary parts: constructing the system frontend, backend, and integrating the two. The frontend construction focused on building the user interface with which the user directly interacts. It was developed using vanilla HTML5, CSS3, and JavaScript, ensuring a lightweight, high-performance application. A component-based architecture with ES6+ modules promoted code reusability. For core features, Chart.js rendered interactive financial charts and jsPDF enabled client-side report generation.

The backend was constructed to perform core functions instructed by the user via the frontend. Its responsibilities included data processing, transaction analysis, and managing business logic. This was accomplished using the Flask framework, which provided a lightweight and flexible environment for building RESTful APIs to handle data processing, anomaly detection, and report generation logic.

The integration of the frontend and backend created a complete, operational system, allowing the frontend to communicate user commands to the backend for execution. For data persistence, SQLite, a serverless relational database, was integrated to store structured financial data, including user information and transactions. Furthermore, security was implemented using JSON Web Tokens (JWT) for user authentication and access control. The entire project utilized a GitHub Actions CI/CD pipeline for automated testing and deployment.

V. SYSTEM IMPLEMENTATION

This section presents the implementation of the system. It will take into account the system design and device requirements defined in the previous section to create a system that functions as required. The frontend andbackend will both be implemented using the specified tools, and then they will be integrated together to make a complete system. The system will then be subjected to rigorous testing where potential users will use itbriefly but intensely to confirm that it operates as specified and addresses the problems it was created to solve.The feedback from the participants of the test is gathered and assessed.

A. *System Operation*

The developed web application features a secure user registration and login gateway. Upon authentication, users are directed to a central dashboard. The dashboard is the primary interface for financial analysis and is divided into three main components,

Figure 11. show the login page. Data upload and control panel allows users to upload financial data in CSV or Excel format and apply dynamic filters for date range, transaction type, and currency. Interactive visualization panel as seen in Figure 12, Figure 13, Figure 14 and Figure 15 show the central panel displays the financial data through a series of synchronized charts powered by Chart.js, including a waterfall chart for net cash flow, pie charts for revenue and expense breakdowns, and a line graph for monthly trends. The node-edge visualization provides a graphical map of fund movements between accounts. Anomaly detection panel as seen in Figure 16 show a table that contain lists of all transactions flagged as anomalies by the IQR algorithm, providing details such as date, amount, and the reason for the flag.

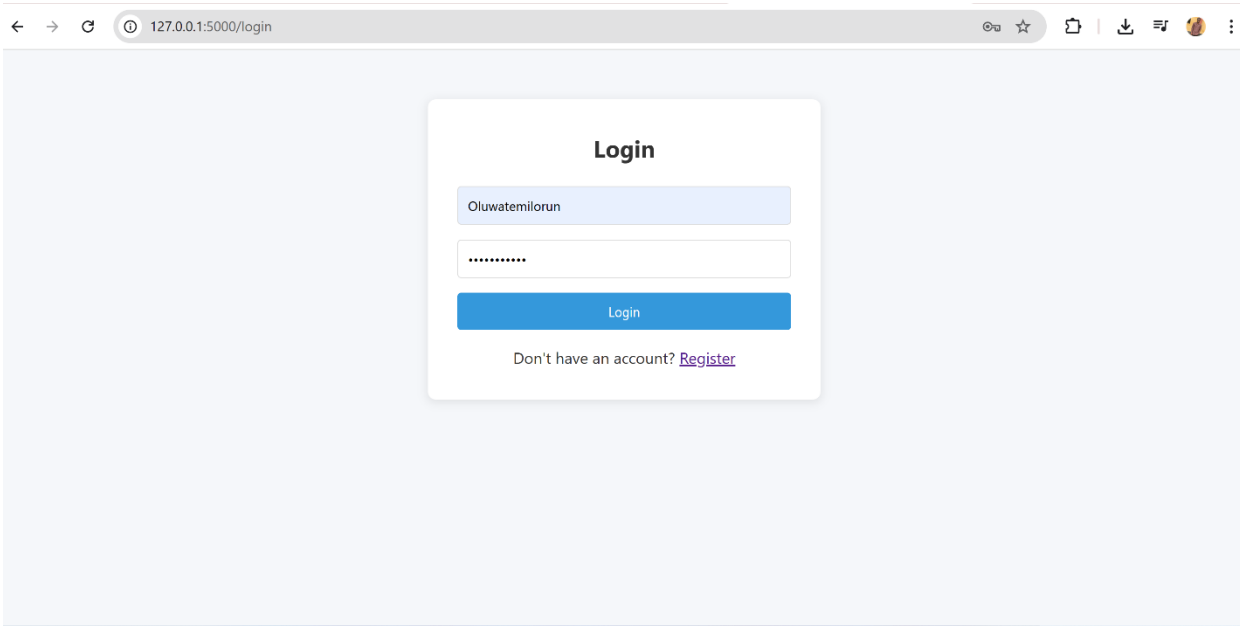

Fig. 11. User Login Page

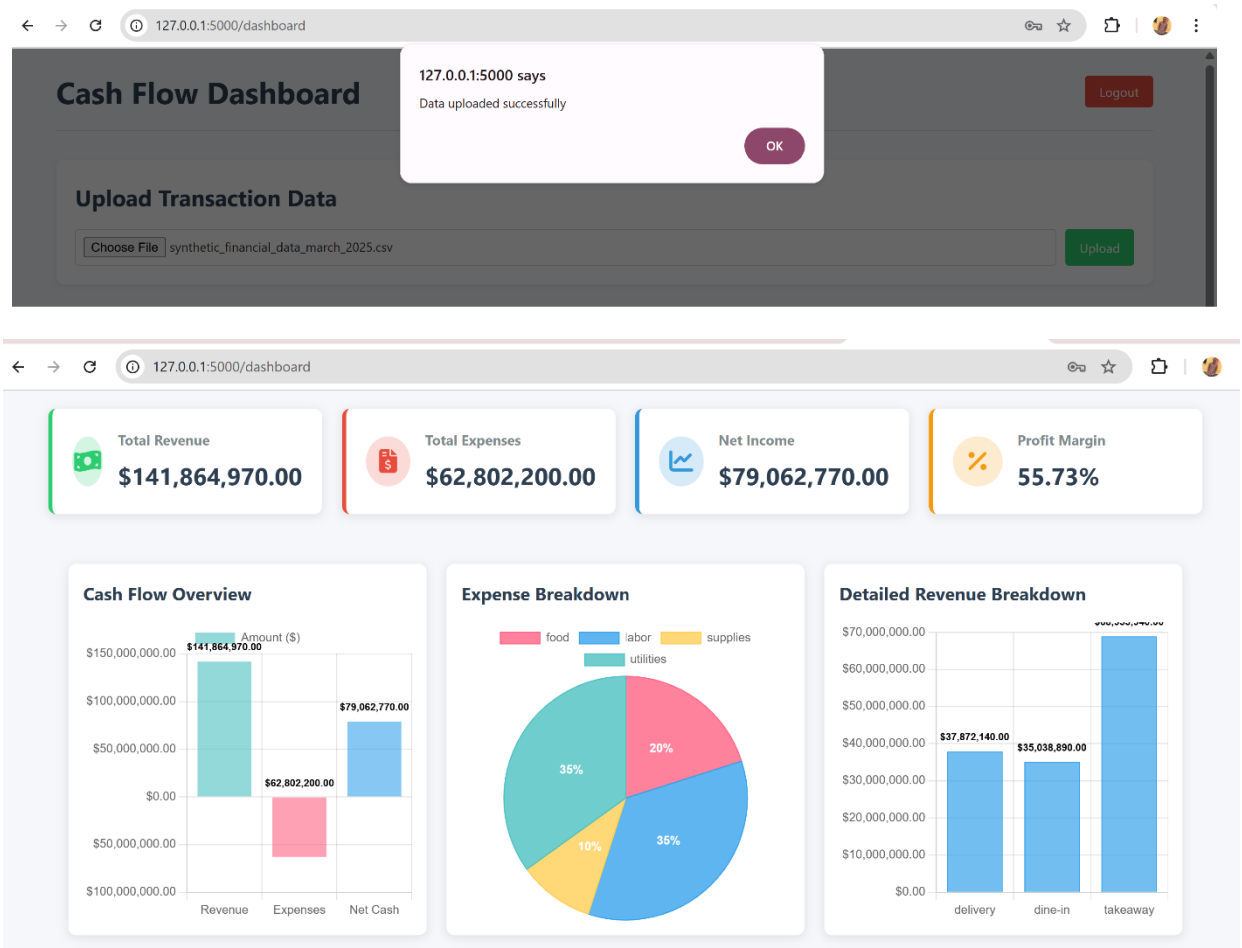

Fig. 12. Interactive Visualization

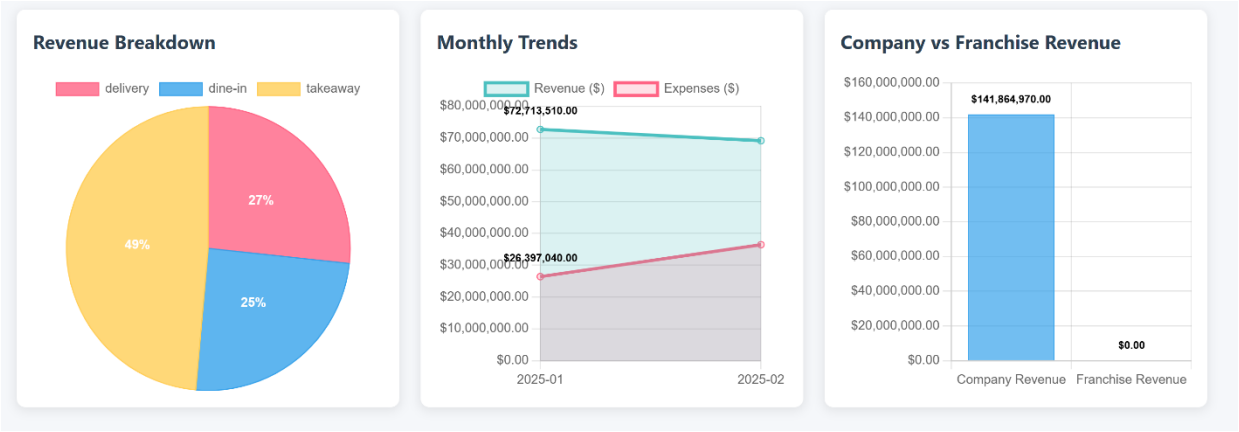

Fig. 13. Interactive Visualization



Fig. 14. Interactive Visualization

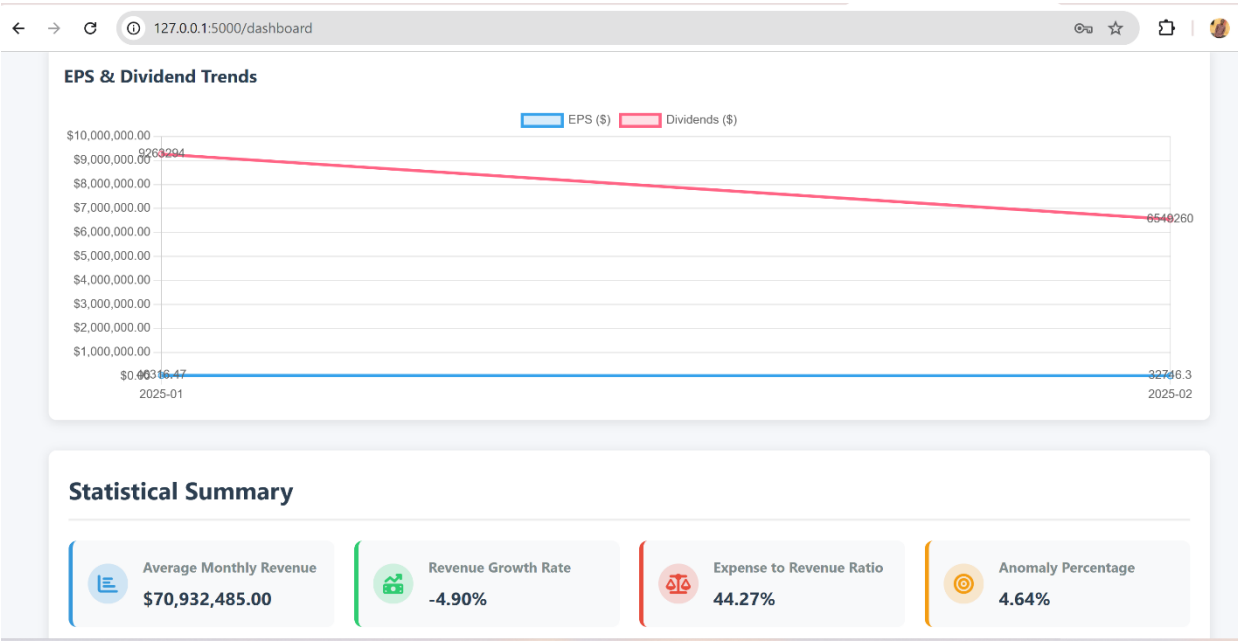

Fig. 15. Interactive Visualization

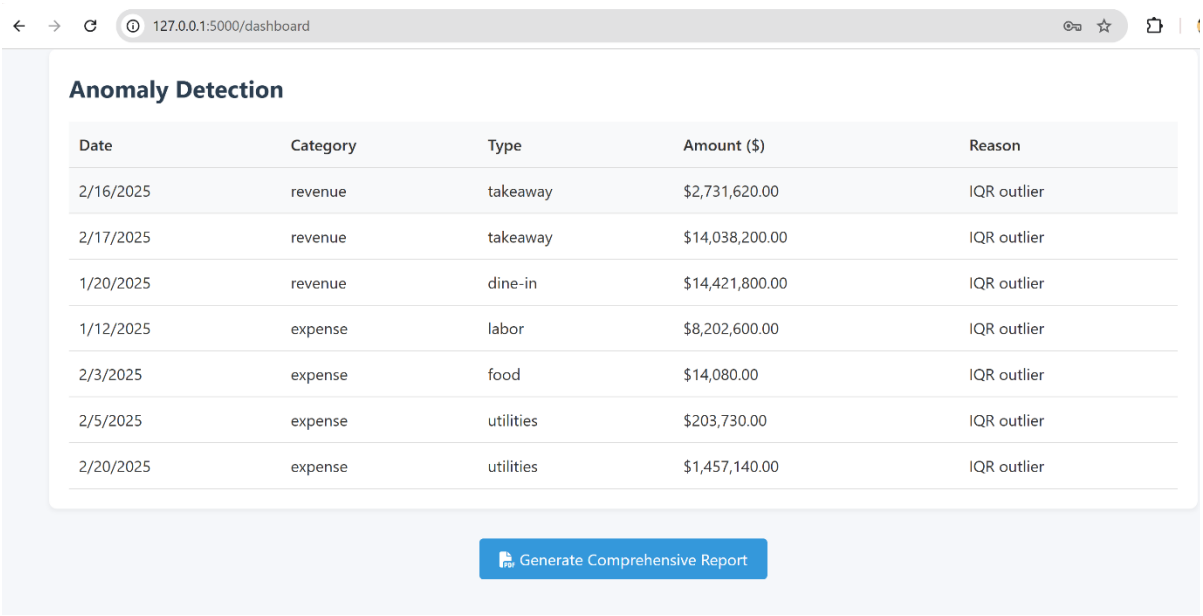

Fig. 16. Anomalies Detected

VI. SYSTEM TESTING

The system's performance was benchmarked to assess its efficiency and scalability. In tests processing datasets of up to 10,000 transactions, the system maintained an average response time of under two seconds for data loading and visualization rendering.

As seen in Table 5 and Figure 17 The accuracy of the anomaly detection algorithm was a key evaluation metric. Using a synthetic dataset with pre-seeded anomalous transactions, the IQR-based algorithm achieved a detection accuracy of 96.2%. False positives were minimal and primarily occurred in scenarios with extremely high data variance.

A user efficiency study was conducted with a small group of alpha testers, including individuals with financial backgrounds. The results showed that users were able to complete common financial analysis tasks (e.g., identifying the largest expense category for a quarter, tracing a series of inter-account transfers) 2.4 times faster using the visualization tool compared to performing the same tasks in a traditional spreadsheet as seen in Figure 18

Table 5. Percentage summaries of participant response to questions regarding the mobile App

Metric Category	Test Parameter	Result	Notes
System Performance	Dataset Size	Up to 10,000 transactions	Maximum tested capacity
	Average Response Time	< 2 seconds	Data loading & visualization rendering
	Scalability Status	Maintained	Performance consistent across dataset sizes
Anomaly Detection	Algorithm Type	IQR-based	Interquartile Range method
	Detection Accuracy	96.2%	Tested on synthetic dataset
	False Positives	Minimal	Occurred mainly with extreme data variance
	Test Data	Pre-seeded anomalies	Controlled synthetic dataset
User Efficiency	Study Participants	2 alpha testers	Senior business analyst & data analyst
	User Background	Financial expertise	Both with relevant domain knowledge
	Task Completion Speed	2.4x faster	Compared to traditional spreadsheet
	Test Scenarios	Common financial analysis	Expense categorization, transfer tracing
	User Satisfaction	4.7 / 5	Based on alpha tester feedback survey.

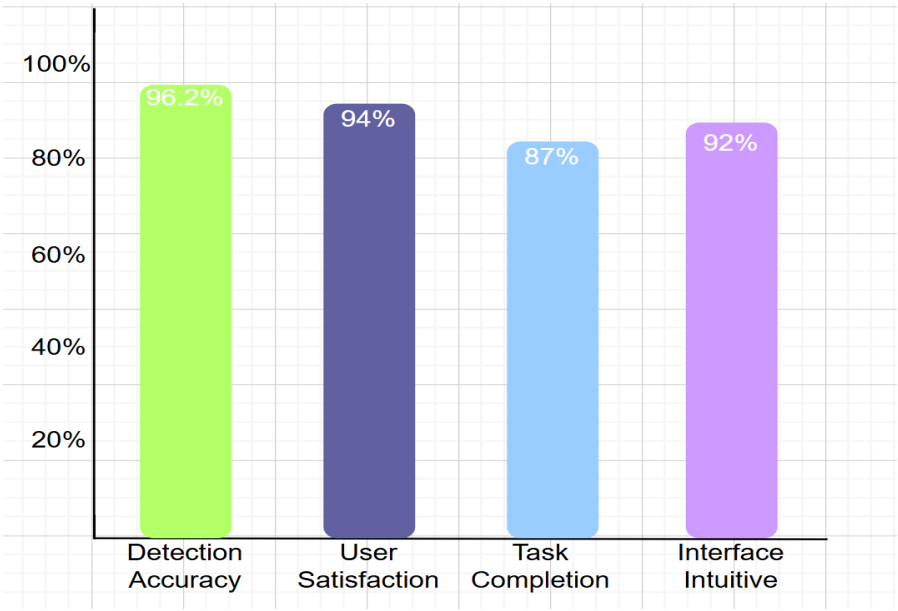

Fig. 17. Performance Metrics

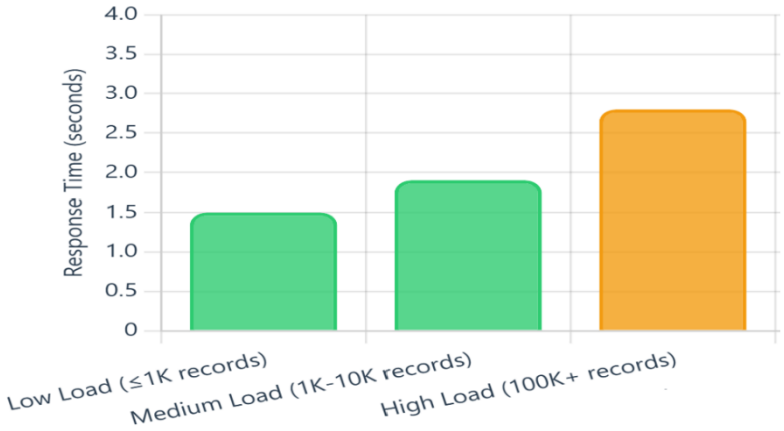

Fig. 18. Response Time

VII. RESULTS AND DISCUSSION

The results of this study demonstrate the significant potential of interactive, web-based visualization tools to revolutionize cash flow management for SMEs. The high accuracy (96.2%) of the IQR-based anomaly detection algorithm confirms that robust statistical methods can be effectively integrated into user-friendly applications to provide a powerful layer of financial oversight. This automated capability directly addresses a major limitation of manual analysis, where such irregularities can be easily missed.

Furthermore, the 2.4x improvement in analysis speed highlights the profound impact of well-designed visualizations on user efficiency. By translating complex numerical data into intuitive graphical formats, as advocated by [6], the tool reduces cognitive overhead and allows users to derive insights more rapidly. The positive feedback on usability suggests that the decision to use a clean, vanilla JavaScript frontend and a focused feature set successfully balanced power with accessibility, a crucial factor for adoption within SMEs where dedicated financial analysts may be a luxury.

The findings align with the broader trend in fintech towards democratizing access to advanced analytical tools [12]. While enterprise-grade systems have long offered similar capabilities, this research demonstrates that a lightweight, web-based architecture can deliver comparable value at a fraction of the complexity and cost. The node-edge visualization, in particular, proved to be a novel and effective method for untangling the complex web of inter-account transfers, a common pain point in financial analysis.

VIII. IMPLICATION FOR RESEARCH AND PRACTICES

This research offers several important implications. For research, it presents a validated, replicable framework for developing and ethically testing financial analysis tools using synthetic data, mitigating privacy concerns associated with real financial records. It also contributes to the literature on human-computer interaction in finance by demonstrating the efficacy of specific visualization techniques (node-edge graphs) and design principles (user-centered, minimalist design) in a financial context.

For practice, the developed tool provides a tangible solution for SMEs seeking to improve their financial management. Business owners and managers can leverage the system to gain a clearer, real-time understanding of their cash flow dynamics, identify inefficiencies, detect potential fraud, and make more agile, data-informed strategic decisions. The accessibility of the web-based platform removes barriers to entry, requiring no specialized software or hardware installation. Financial advisors and accountants can also use the tool to provide more effective, visually-driven consulting services to their SME clients.

IX. LIMITATIONS

Despite the promising results, this study is subject to several limitations that threaten its validity. The primary threat to external validity is the use of synthetic data. While carefully structured to mimic real-world scenarios, it cannot fully capture the nuances, noise, and unpredictability of actual business financial data. The system's performance and accuracy may differ when applied to real, messy datasets. Another threat is the limited scope of the user evaluation. The feedback was gathered from a small group of alpha testers; a larger, more diverse user study would be necessary to generalize the findings on usability and effectiveness. Finally, the study focuses on a specific set of visualization and analysis techniques. The chosen methods may not be optimal for all types of financial analysis or all business contexts, representing a threat to construct validity.

X. CONCLUSION AND FUTURE WORK

This project successfully designed, developed, and evaluated an interactive web-based tool for cash flow visualization and analysis. By integrating dynamic visualizations, granular filtering, and automated anomaly detection into a user-friendly platform, the system effectively addresses critical gaps left by traditional financial analysis methods. The results confirm that such a tool can significantly enhance the speed, accuracy, and depth of financial insight available to SMEs, thereby empowering better decision-making and mitigating financial risk. The research validates a practical and ethical methodology for building and testing fintech solutions.

Future work will proceed in several directions. First, we plan to enhance the system by integrating machine learning algorithms for predictive cash flow forecasting, allowing users to move from historical analysis to forward-looking strategy. Second, we will work towards integration with popular accounting software (e.g., QuickBooks, Xero) via APIs to streamline the data import process. Third, a large-scale beta testing program with real-world SMEs will be conducted to further validate the tool's performance and gather feedback for iterative improvement. Finally, expanding the tool's capabilities to include collaborative features, such as multi-user dashboards with role-based access, will be explored to support team-based financial management.

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