

SpendSense-AI: An Intelligent Personal Expense Tracking and Financial Insight System

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Abstract—Financial management of a person has become one of the problems in modern technological world because of the increased amount of transactions through the Internet and low user awareness about his own expenses. It is hard for users to control and analyze his own expenses that causes poor budgeting and unstable financial condition. The paper introduces SpendSense-AI system as a tool for systematic tracking, categorizing and analysis of user's expenses. In contrast to other existing applications that deal only with data capturing and storing, our approach pays special attention to interpretation, simplicity and user-oriented analysis. User will be able to find out the most expensive categories, track changes every month and make right decisions regarding his financial condition without having any financial background. In order to achieve maximum effectiveness, the workflow is defined. According to experimental evaluation by use of representative sample datasets, the system has improved usability, reduced manual effort as well as increased financial awareness among the users. It has been shown that even a simplistic and uncomplicated analysis approach can be very helpful in improving financial management. Moreover, the system has been made scalable and adaptive, which makes it ready for practical implementation. Possible improvements may involve incorporating predictive models along with financial information sources.

Index Terms—Expense Management, Financial Analytics, Personal Finance, Intelligent Systems, Data Visualization.

I. INTRODUCTION

In light of the proliferation of digital payment systems and services, people find themselves making a substantially greater number of transactions compared to the past. The increased transaction rate complicates personal financial management to a certain extent and leads to problems associated with the monitoring of expenses and control over one's

budget. This causes the users to face situations where unexpected expenses are incurred and budgets are not managed efficiently. The traditional approach to the process of financial management involves the use of notebooks or spreadsheets to register information about money spent. Such an approach is not only very laborious but also quite prone to errors. While there have been attempts at creating various mobile apps that help track one's spending, most of them provide little in terms of interpretation of the gathered data. In order to overcome such shortcomings, this paper presents the concept of SpendSense-AI, which is an intelligent expense management system aimed at facilitating personal finance awareness via analysis of expenditure patterns. In particular, the system allows its users to input their expenditures, automatically classify these expenses, and conduct their analysis with the help of intuitive visualizations. With the use of rulebased analysis methods, the system delivers simple but effective tips that help its users recognize unnecessary expenses. Different from other financial apps that need integration into bank infrastructure or machine learning models, the introduced solution is easy to use and understand. The proposed SpendSense-AI: An Intelligent Personal Expense Tracking and Financial Insight System is projected to offer an economic, intelligent, and user-friendly solution for managing one's personal finance. In the system, the users will be able to enter their daily expenditures in an efficient manner either manually or through receipts scanning using Optical Character Recognition (OCR), and thus saving time and making fewer mistakes during the data entries. The users will be able to classify their expenses in pre-defined categories such as food, transportation, shopping, health care, education, entertainment, bills, rent, and travels, thereby keeping a systematic account of their

finances. For better understanding of the user, the details are provided in the form of interactive dashboards, charts, graphs, and statistics, thereby making the financial data easy to understand. The architecture designed for this is lightweight and scalable, and can be deployed for practical purposes with very less computational overhead. This architecture has a modular structure, which makes it easy to expand this framework and add functionalities such as online banking, payment gateway services, multi-lingual OCR capabilities, cloud storage facility, and other AI models. In addition, this system makes use of AI and machine learning methods to analyze the expenditure patterns of the users and provide predictions of their future expenses along with personalized financial advice. In addition, it calculates several important financial metrics such as Financial Health Score, Budget Utilization, Monthly Savings, and Spending Growth.

II. LITERATURE REVIEW

A. Behavioral Foundations of Personal Finance Knowledge about the way people make their decisions regarding finances plays an important role in the development of efficient expense tracking systems. It has been proved that people tend to think irrationally due to a wide variety of cognitive biases and heuristics, and not in the ideal rational manner that is characteristic of a purely rational approach [1]. Following that line of thought, Thaler [2] discussed ways in which behavioral economics could be applied to personal finance and showed that such aspects as framing, defaults, and simplification of choice play a great role in saving and spending behavior. B. Big Data and Analytics in Financial Systems The emergence of big data has revolutionized the field of financial services. In their analysis of big data analytics and its influence on decision-making, risk management, and customers in finance, Akter and Wamba [3] identified several areas of interest. Manyika et al. [4] analyzed the age of analytics and showed how the industry is changing thanks to new data-based methods that provide more precise and personal results. McAfee and Brynjolfsson [5] focused on incorporating machine learning techniques into business practice and noted that nowadays, predictions play a crucial role in the decision-making process—a feature that SpendSense-

AI uses to generate personalized financial insights. Hilbert [6] offered some more insights regarding big data and its implementation in developing countries with an accent on the necessity of affordable and usable analytics in poor regions. C. Artificial Intelligence and Machine Learning Techniques The intelligent financial systems technology is based on extensive studies performed in AI and ML disciplines. Russell and Norvig [7] introduced the theoretical basis of the intelligent agents design which can be used when constructing the architecture of the intelligent insight generation system. The overview of the trends and perspectives in machine learning and role of rule-based and data-based approaches in this discipline were provided by Jordan and Mitchell [8]. Shalev-Shwartz and Ben-David [9] presented a theoretically oriented description of the learning algorithms with the foundation of the classification algorithm implemented in SpendSense-AI. XGBoost—gradient boosting algorithm for tabular data—was developed by Chen et al. [10] and is widely used in the classification tasks related to expense categories and spending prediction—the task which is performed in the classification engine of SpendSense-AI. Han, Kamber, and Pei [11] give an overview of the basic data mining concepts such as classification, clustering and pattern detection, all of which could be used in detecting spending patterns and outliers. Apart from traditional techniques, the advances brought about by deep learning in the pattern recognition capability necessary for intelligent finance systems have been significant. LeCun, Bengio and Hinton [12] and Goodfellow, Bengio and Courville [13] gave an overview of the revolutionary influence of deep learning on pattern recognition and predictions, while He et al. [14] illustrated the deep residual network architecture that is capable of performing highly accurate visual recognition – techniques which are relevant to the receipt scanning OCR module in SpendSense-AI's AI service integration. Going beyond the existing rule-based system, Sutton and Barto [15] proposed the technique of reinforcement learning for sequential decision making, a potential area for development of the system. Géron [16] gave useful advice based on Scikit-Learn and TensorFlow, guiding the process of implementing SpendSense-AI. D. Data Visualization and User Interpretability Actionable insight delivery being one of the core aspects of SpendSense-AI, data

visualization becomes crucially important. Not many [17] have taken into consideration the principles of human perception in developing visualizations of financial data, thereby minimizing their cognitive loads — a very important aspect of the system's dashboard and insights delivery features. E. Smart Applications and Domain-Specific Tools Earlier research on domain-specific AI applications provides additional insights into the positioning of SpendSense-AI. Kitchin [18] investigated data-driven smart city programs, highlighting the way big data integration can result in adaptive and responsive systems — a concept that is replicated by individual-level data in personal finance applications. Vaidyanathan [19] reviewed the existing trends and challenges in personal finance applications, highlighting the need for personalization, engaging features, and good prediction abilities — aspects which SpendSense-AI aims to address using artificial intelligence. F. Recent Advances in AI-Driven Personal Finance Tools RThere is an increased recent interest in direct application of artificial intelligence in personal finance and expenditure tracking, which aligns closely with the purpose of the current work. Ashraf et al. [20] considered the increasing application of artificial intelligence in fintech and the way that it is revolutionizing customer-facing financial services, which is the motivation behind AI-assisted receipt recognition and interpretation in SpendSense-AI. Bhatia [21] investigated the application of AI technologies to personal finance management, strengthening the argument for developing user-friendly budgeting tools based on artificial intelligence. Gupta and Sharma [22] developed an intelligent system for expense tracking, which could be regarded as the most direct competitor to SpendSense-AI in automated categorization and tracking features. However, in contrast to SpendSense-AI, such systems are more focused on gathering information rather than making it understandable and easily usable by the users. In their latest research, Kumar and Singh [23] studied the development of intelligent financial analytics for personal budgeting.

III. IMPLEMENTATION

In addition, the suggested system has been designed by means of utilizing several advanced technologies

to ensure its successful implementation. The architecture of the system makes use of the client-server architecture, wherein the client side handles the user interface part whereas the server side takes care of the data processing and storage. A. Technology Stack SpendSense-AI generation process utilizes advanced and efficient technology stack that guarantees high performance and supports interactive designing and interaction. All technologies have been selected for their specific functionality within the system, for example, designing user interface, visualizing data, and implementing interactive animations.

1) Frontend Framework: React 18 with TypeScript: The React 18 framework with TypeScript has been used to develop the frontend of SpendSense-AI. This is a good foundation to build an interactive single page application. The React 18 framework employs the component approach, which allows for the decomposition of the user interface into reusable components. TypeScript is the language that brings static typing into JavaScript and helps create reliable, maintainable, and debuggable code at the stage of writing it. With the use of React and TypeScript, it is possible to develop a really responsive frontend architecture.

2) Styling: Tailwind CSS v4 with Neo-Brutalist Design System: The visual styles of the application are done with Tailwind CSS v4. Tailwind CSS is a utility first CSS framework that allows one to build their user interface quickly and consistently through utility classes. It reduces the amount of custom CSS code written. A custom design style known as Neo Brutalism is adopted to give the application a unique visual identity. Such a design style focuses on bold layout, solid borders, contrast, and geometry, which creates a modern and visually compelling user interface.

3) Animations: Framer Motion: Framer Motion allows implementing interactive and smooth animations throughout the app. It provides a better user experience as it introduces animated transitions, motion effects, and interaction animations within the UI components. Animations make the dashboard more visually responsive and engaging for users. This software is very helpful during the creation of animation charts, modal transition, interactive cards, and feedback elements.

4) Data Visualization: Chart.js: This software is used for finance data visualization. The software enables visualization of expense data using visual elements such as bar graphs, line graphs, and pie charts. Through the data visualization functionality, the user can understand how he or she is spending their money.

5) Icons: Lucide React: The Lucide React library is chosen for the icon library for the app. The library consists of lightweight, scalable, and customizable vector icons. Icons help represent the various elements of the software interface visually in an intuitive way. Icons make the usage of the software more intuitive and help in designing a clean interface.

6) Build Tool: Vite: The use of Vite is employed as the build tool in the course of the project's development and deployment process. It offers fast development server booting, hot module replacement, and optimized production builds. In contrast to other build tools, Vite considerably increases the speed and performance of development.

7) AI Services Integration: SpendSense-AI incorporates artificial intelligence functionality via Gemini API for smart analysis of finances and receipt scanning using OCR. The AI component is to be used for extracting information about the transactions from receipts and for analyzing financial behavior as well as giving out recommendations accordingly. This incorporation makes the system more intelligent as it can interact with finances in a natural way.

8) Overall Significance of the Technology Stack: SpendSense-AI will be modern, scalable, efficient, and userfriendly because of the choice of the technology stack. This will involve frontend performance, analytics, interactive visualizations, and efficient deployment of the solution, thus being ideal for personal financial management application.

The system has been structured into several different functional modules to make it more manageable and efficient:

- User Input Module: Helps in the entry of expense details through the form. The validation of the input is performed to ensure that the data is accurate and complete.
- Data Management Module: Helps in storing, retrieving and updating the data in the database regarding the expenses.
- Categorization Module: Helps in the categorization of each expense in a particular category depending upon the user input or predefined rules.
- Analysis Module: Helps

in the analysis of the data stored to compute the total expenditure, expense categorization and trends in a month.

- Visualization Module: Helps in visualizing the financial data through various graphical tools such as bar graph and pie chart.

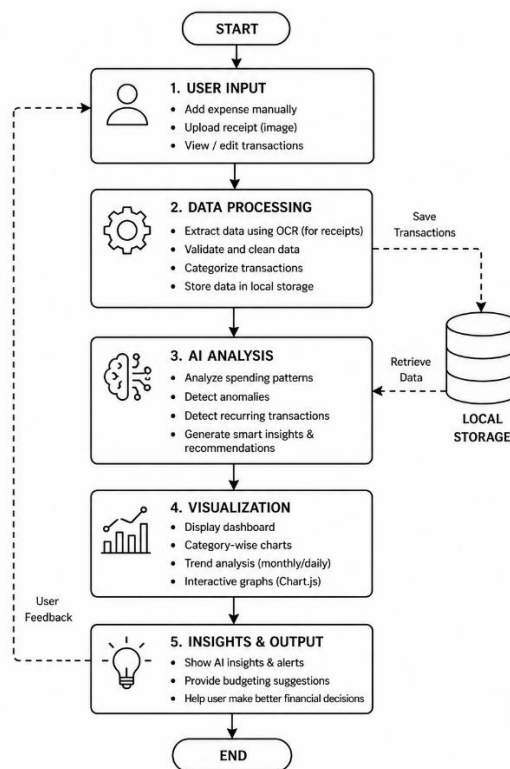


Fig. 1. System Architecture of SpendSense-AI System Modules

Functional Workflow Operations Flow Follows The Following Process:

1. Entering of expense data by the user in frontend stage.
2. Processing of data by the backend.
3. Recording of transaction in the database in structured format.
4. Expense gets categorized by the categorization module.
5. Statistical summary and trends get computed by analysis module.
6. Graphical representation of processed data using visualization module.
7. Recommendations generated by insight module based on spending habits.

User Functionalities Some of the functionalities offered by the system to the end user includes:

- Add Expenses: Users can add details about day-to-day expenses.
- Categorized Data Viewing: Expenses get categorized for better understanding.

- Trend Analysis: Trends of monthly expenditures as well as category-wise expenditure trends can be analyzed.
- Modification/Deletion: Entries made previously can be modified or deleted.
- Graphical Dashboard Interface: Graphically view their finances.

B. Financial Health Score (FHS) Financial Health Score (FHS) is used to evaluate the overall financial health of the user through different financial indicators. Financial health score (FHS) includes elements like savings, budgeting efficiency, expenditure stability, and debt management.

FHS with high value represents stability in the financial status and good spending habits. On the contrary, a low value indicates that the user must learn how to manage his finances better.

Where: S = Savings BS = Budget Score EC = Expense Consistency DS = Debt Score

$$FHS = \frac{S + BS + EC + DS}{4}$$

C. Budget Utilization (BU)

Budget Utilization (BU)

C. Budget Utilization is an indicator which shows the part of the budgeted sum spent by the user during some period. The measure provides information on the efficiency of spending by the user of the budgeted sum. When the value of the indicator is close to 100%, the user spends the budgeted sum efficiently, and more than 100% – overspends.

$$BU = \frac{\text{Actual Expense}}{\text{Allocated Budget}} \times 100$$

D. Monthly Savings Monthly Savings measures the sum that could be saved by the user after all expenses were deducted from his/her monthly income. It represents one of the most important indicators of the financial state of the user.

Savings = Income – Expenses

E. Spending Growth Spending Growth is the growth rate of expense from one month to another expressed in percentage terms. This can be useful for understanding the growth trend of expenses so that

any abnormal spending behavior can be detected early enough to give financial advice.

$$\text{Growth} = \frac{\text{Current Month}}{\text{Previous Month Previous Month}} \times 100$$

IV. RESULTS AND DISCUSSION

This system was tested by creating some sample datasets of transactional information from various categories including food, transport, utility costs, and recreation among others. The purpose of testing this system was to evaluate its effectiveness in terms of usability and the insights it would generate. This test involved feeding the data into the system for processing during a specific period of time. Graphical representation of the processed data was done for evaluation purposes. Observations • Enhanced Financial Tracking System: It allows the systematic and efficient tracking of financial transactions, thereby minimizing any possibility of omissions or duplications in financial transactions. • Proper Categorization of Expenditure: There is a proper categorization of financial transactions, and hence users find it easy to know how their money has been spent. • Efficient Data Visualization: Bar graphs and pie charts provide an intuitive visualization of users' expenditure trends. • Financial Assistance: The rules-based insight module will help to highlight areas where expenses are very high and give advice on how to manage the unnecessary expenses.

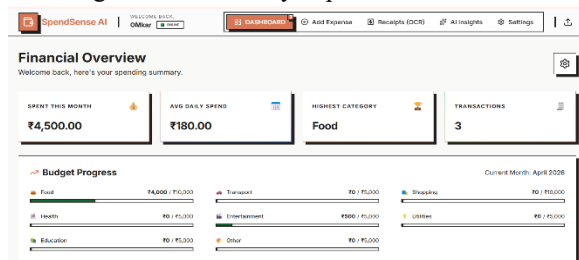


Fig. 2. Financial Dashboard

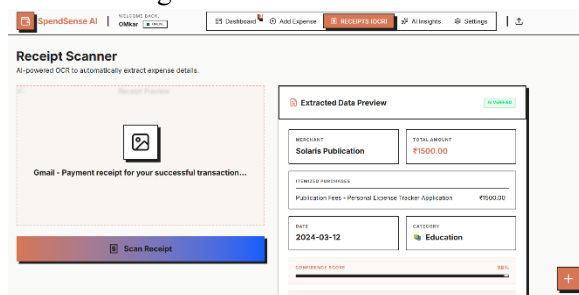


Fig. 3. Receipt Scanner (OCR)

Performance Analysis

The efficiency of the system is greater than the efficiency of conventional ways to record expenses manually. Manual systems imply that data is dispersed in various places and there is a lot of effort required for analyzing them, whereas the proposed system automates this process. With regard to usability, the user has the opportunity to easily input and retrieve the information about financial situation thanks to an easy-to-use interface. The utilization of the categorization and visualization components reduces the cognitive load associated with the complex data structure, and the insights generation component makes decision-making easier. Even though the system does not employ any advanced machine learning models, yet its performance is quite satisfactory because of effective data processing and analysis through rules.

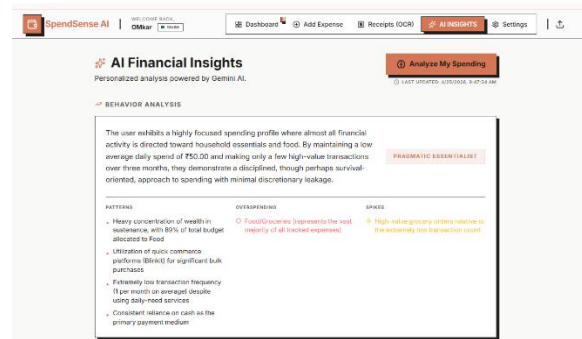


Fig. 4. AI Financial Insights

Discussion

As can be noted from the findings above, integration of expense tracking with visualizations and analysis helps in improving the financial literacy of the users. They now have the chance to monitor their expenses and act accordingly. Nevertheless, there are some limitations of the system. Insights accuracy is subject to correct user's input and categorization rules. Also, the lack of predictive analytics restricts the forecasting abilities of the system. Nevertheless, even with these limitations, the proposed system is still an effective way of organizing one's financial life. This is a combination of efficiency and simplicity, thus making it accessible to many people

V. CONCLUSION

SpendSense-AI: An Intelligent Personal Expense Tracking and Financial Insight System is an efficient

and intelligent solution to the modern issue of financial management through the incorporation of AI, ML, OCR, and interactive data visualization into one integrated platform. The system manages to automate the process of expense recording using the receipt scanning process, categorize the expenses into pre-defined classes, and analyze the spending behavior of users generating valuable financial insights. This automation decreases manual Fig. 3. Financial Dashboard Fig. 4. Financial Dashboard work significantly, decreases errors in data entry, and increases the efficiency of the whole process of expense management. The incorporation of the machine learning algorithms into the system allows finding out the spending habits of users, make predictions about expenses in the future, and helps users make well-informed financial decisions. Furthermore, the financial indicators incorporated into the system (Financial Health Score, Budget Utilization, Monthly Savings, and Spending Growth) increase the analytical capacities of the system giving the user a comprehensive analysis of their financial state. Intelligent recommendations and visual dashboards give an ability to get the understanding about user's spending behavior using charts, diagrams, and mathematical calculations. The described architecture is simple, flexible, and easy to implement. Consequently, it can be implemented by students, professionals, families, and entrepreneurs. Modularity of the proposed architecture gives an opportunity to incorporate new features and technologies into the software. In addition, the implementation demonstrates the opportunity of using AI financial analytics in order to simplify the process of personal financial management. SpendSense-AI has successfully combined such features as automated expense management, intelligent financial analysis, predictions, and visualization into one system. Therefore, the developed system can be considered as the practical solution to the problem of personal finance management and the base for future research in the area of AI-based financial intelligence systems.

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