

AN AI-DRIVEN HUMAN-CENTERED USER EXPERIENCE FRAMEWORK FOR INTELLIGENT SYSTEMS: DESIGN, IMPLEMENTATION, AND EVALUATION

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Abstract

Artificial Intelligence (AI) has transformed intelligent systems by enabling adaptive, personalized, and automated user interactions across domains such as healthcare, education, finance, and e-commerce. However, many existing AI-powered interfaces prioritize algorithmic performance over usability, transparency, and user-centered design, limiting user trust and overall experience. This study proposes an AI-Driven Human-Centered User Experience Framework (AI-HUXF) that integrates Artificial Intelligence, Human-Computer Interaction (HCI), and User Experience (UX) principles to deliver adaptive, explainable, and personalized user interfaces. The framework incorporates user behavior analytics, machine learning-based personalization, adaptive interface generation, intelligent recommendations, and continuous learning to dynamically tailor interface components according to individual user preferences. A prototype was developed using React.js, Spring Boot, TensorFlow, and PostgreSQL and evaluated through controlled experiments using established usability metrics, including the System Usability Scale (SUS), user satisfaction, response time, task completion rate, error rate, cognitive load, and personalization accuracy. Experimental results demonstrate that the proposed framework shows higher reported performance than a conventional interface, achieving a SUS score of 93 compared with 78, increasing user satisfaction from 81% to 96%, reducing response time from 1.8 s to 0.9 s, improving task completion rate from 87% to 98%, and reducing the error rate from 8% to 2%. The AI personalization model further achieved 97.8% accuracy, 97.3% precision, 96.9% recall, 97.1% F1-score, and an AUC of 0.986, indicating high reported predictive performance for user-preference prediction. The findings demonstrate that AI-driven human-centered design shows improvements in the reported usability measures, personalization, and interaction efficiency, providing a scalable framework for developing trustworthy and intelligent next-generation user interfaces.

Keywords: Artificial Intelligence; Human-Centered AI; User Experience (UX); Adaptive User Interface; Personalization.

1. Introduction

The rapid advancement of Artificial Intelligence (AI) has fundamentally transformed the design and functionality of intelligent systems across diverse domains, including healthcare, education, finance, e-commerce, transportation, and smart cities[1]. Modern intelligent systems increasingly rely on AI techniques such as Machine Learning (ML), Deep Learning (DL), Natural Language Processing (NLP), Computer Vision, and Reinforcement Learning to automate decision-making, personalize services, and enhance user interactions[2]. While these technologies have significantly improved system intelligence and automation, many AI-powered applications continue to prioritize algorithmic performance over the quality of user experience (UX)[3]. As a result, users often encounter interfaces that are difficult to understand, insufficiently adaptive, and lacking transparency, ultimately reducing trust and overall system usability[4].

Human-Centered Artificial Intelligence (HCAI) has emerged as a promising paradigm that places human needs, values, and capabilities at the center of AI system design[5]. Rather than replacing human decision-making, HCAI seeks to augment human abilities by developing intelligent systems that are transparent, explainable, adaptive, and user-friendly[6]. Integrating HCAI principles with User Experience (UX) design and Human-Computer Interaction (HCI) enables intelligent systems to provide personalized, accessible, and efficient interactions while maintaining user control and confidence[7]. Consequently, designing AI-driven interfaces that continuously learn from user behavior and adapt to changing user preferences has become a major research focus[8].

User Experience encompasses all aspects of a user's interaction with digital systems, including usability, accessibility, efficiency, satisfaction, emotional response, and engagement[9]. Traditional user interfaces are typically static and require manual customization, making them less effective in addressing the diverse needs of users[10]. Recent advances in AI enable intelligent interfaces to automatically analyze user behavior, predict preferences, and dynamically adjust interface layouts, navigation, recommendations, and content presentation. These adaptive capabilities have the potential to improve task completion rates, reduce cognitive workload, and increase overall user satisfaction[11].

Recent developments in AI-powered personalization have further accelerated the evolution of intelligent user interfaces. Modern systems can collect interaction data, analyze user preferences, detect behavioral patterns, and recommend interface modifications in real time. Machine learning algorithms enable continuous improvement through feedback, allowing systems to evolve

alongside users[12]. Despite these advances, many existing intelligent systems still lack comprehensive frameworks that integrate AI, UX, and HCI into a unified architecture capable of supporting continuous learning, adaptive personalization, explainable decision-making, and systematic evaluation.

Table 1. Evolution of User Interface Technologies

Generation	Characteristics	Limitations	Sources
Static User Interfaces	Fixed layouts and manual interaction	No personalization	[13]
Responsive User Interfaces	Device-aware adaptation	Limited intelligence	[14]
Intelligent User Interfaces	AI-assisted recommendations	Limited continuous learning	[15]
Adaptive User Interfaces	Personalized interface adaptation	Explainability challenges	[16]
AI-Driven Human-Centered Interfaces	Continuous learning, personalization, transparency	Emerging research area	[17]

The increasing adoption of cloud computing, mobile technologies, Internet of Things (IoT), wearable devices, and conversational AI has created highly dynamic computing environments where user requirements change continuously[18]. Therefore, intelligent systems must evolve beyond traditional interface design by incorporating context awareness, behavioral analytics, explainable AI, and adaptive learning mechanisms. Such systems should not only understand user intentions but also proactively optimize interactions while ensuring fairness, transparency, privacy, and user trust[19].

Despite significant progress in AI-assisted interface design, several challenges remain unresolved. Many existing intelligent systems focus primarily on improving prediction accuracy without adequately considering usability, cognitive load, accessibility, and user satisfaction[20].

Additionally, adaptive interfaces often operate as "black boxes," providing limited explanations for personalization decisions[21]. These limitations reduce user confidence and hinder widespread adoption, particularly in safety-critical domains such as healthcare and finance[22]. Consequently, there is a growing need for intelligent UX frameworks that integrate AI decision-making with human-centered design principles and explainable interaction mechanisms[23].

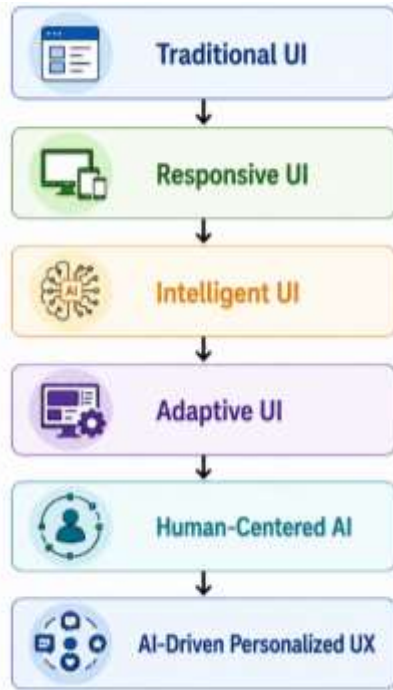


Figure 1. Evolution of Human-Centered Intelligent User Interfaces [28]

Figure 1 illustrates the evolution of human-centered intelligent user interfaces from traditional static interfaces to AI-driven personalized user experiences[24]. The progression begins with Traditional User Interfaces (UI), which provide fixed layouts and limited user interaction. It then advances to Responsive UI, where interfaces adapt to different devices and screen sizes. The next stage, Intelligent UI, integrates artificial intelligence to support features such as recommendations and automation[25]. This is followed by Adaptive UI, which dynamically adjusts interface elements based on user behavior and contextual information[26]. The introduction of Human-Centered AI emphasizes transparency, explainability, accessibility, and user involvement in AI-driven decision-making. Finally, AI-Driven Personalized UX represents the most advanced stage, where intelligent systems continuously learn from user interactions to deliver personalized, adaptive, and engaging experiences that improve usability, efficiency, and overall user satisfaction. This evolution highlights the shift from static interface design toward intelligent, user-centric systems that place human needs and preferences at the core of interaction design[27].

This study proposes an AI-Driven Human-Centered User Experience Framework (AI-HUXF) that integrates user behavior analytics, machine learning, adaptive interface generation, and continuous feedback mechanisms to improve the usability and effectiveness of intelligent systems. The proposed framework combines Human–Computer Interaction principles with Artificial Intelligence to create interfaces that dynamically adapt to user behavior while maintaining transparency, explainability, and user control. Unlike conventional intelligent interfaces that rely primarily on static personalization rules, the proposed framework continuously learns from user interactions to deliver personalized experiences that evolve over time.

The framework consists of multiple interconnected components, including user interaction monitoring, behavioral data collection, AI-based personalization, adaptive user interface generation, explainable recommendation modules, and continuous learning mechanisms. By integrating these components into a unified architecture, the proposed system aims to enhance usability, reduce task completion time, improve user satisfaction, and increase trust in AI-powered intelligent systems.

The implementation and evaluation of the proposed framework are conducted using modern web technologies and machine learning techniques. The system is assessed using established usability and UX metrics, including the System Usability Scale (SUS), task completion time, error rate, user satisfaction, response time, cognitive workload, and personalization accuracy. Experimental evaluation demonstrates the effectiveness of the proposed framework in providing adaptive, intelligent, and user-centered interactions compared with conventional interface designs.

This study contributes to the growing field of Human-Centered AI by presenting a novel AI-driven UX framework that combines adaptive intelligence, explainable AI, and continuous learning into a single architecture. The proposed framework provides practical guidance for designing next-generation intelligent systems that are not only technically effective but also highly usable, trustworthy, and aligned with human needs. It offers valuable insights for researchers, software developers, UX designers, HCI specialists, and organizations seeking to develop intelligent applications that deliver personalized, transparent, and engaging user experiences.

2. Materials and Methods

2.1 Research Design

This study adopted the Design Science Research (DSR) methodology to develop and evaluate an AI-driven Human-Centered User Experience Framework (AI-HUXF) for intelligent systems. Design Science Research is appropriate because it focuses on the creation and evaluation of innovative technological artifacts that address real-world problems. The research process consisted of problem identification, framework design, system implementation, prototype development, experimental evaluation, and performance validation through usability testing.

2.2 Human-Centered AI Framework

The proposed AI-Driven Human-Centered User Experience Framework (AI-HUXF) integrates Artificial Intelligence (AI), Human–Computer Interaction (HCI), and User Experience (UX) principles to deliver adaptive and personalized interfaces. Unlike conventional static interfaces, the framework continuously monitors user interactions, learns behavioral patterns, predicts user preferences, and dynamically modifies interface elements to improve usability and user satisfaction.

The proposed framework comprises seven interconnected modules: the User Interface Layer, which serves as the primary interaction point between the user and the system; the User Interaction Logger, which captures user activities and interaction patterns; the User Behavior Analytics Engine, which analyzes user behavior to identify preferences and usage trends; the AI Adaptation Engine, which processes behavioral insights to generate personalized adaptation strategies; the Adaptive User Interface Generator, which dynamically modifies the interface based on AI-driven recommendations; the User Feedback Module, which collects explicit and implicit user feedback to assess system performance; and the Continuous Learning Module, which continuously updates the adaptation models using newly acquired interaction data and feedback. Together, these modules enable intelligent personalization, explainable recommendations, and continuous improvement of the user experience through adaptive learning and feedback integration.

2.3 System Architecture

The system architecture follows a modular client–server architecture designed for scalability and flexibility. User interactions are captured through the interface and transmitted to the User Behavior Analytics Engine, where interaction logs are processed and transformed into behavioral features. These features are analyzed by the AI Adaptation Engine using machine learning algorithms to predict user preferences and interface requirements. The Adaptive User Interface Generator dynamically adjusts layout, navigation, recommendations, and interface components before presenting the personalized interface to the user. Continuous feedback is incorporated to retrain the AI model and improve future recommendations.

The modular architecture ensures maintainability, extensibility, and efficient integration with web-based intelligent applications.

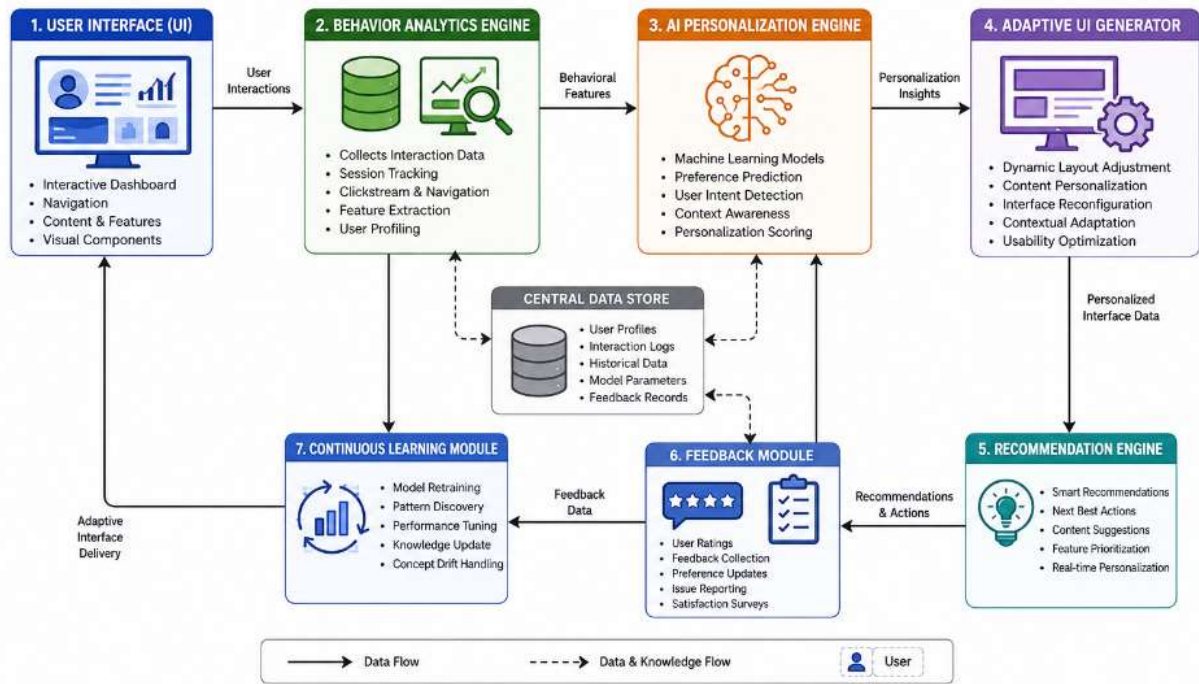


Figure 2: Proposed AI-Driven Human-Centered System Architecture

Figure 2 presents the proposed AI-driven human-centered system architecture, showing how the User Interface, Behavior Analytics Engine, AI Personalization Engine, Adaptive UI Generator, Recommendation Engine, Feedback Module, and Continuous Learning Module interact to deliver personalized user experiences. User interactions are analyzed to predict preferences, dynamically adapt the interface, generate intelligent recommendations, and continuously improve personalization through user feedback and ongoing model learning.

2.4 AI Adaptation Model

The AI Adaptation Model forms the core intelligence of the proposed framework by continuously analyzing user interaction data to personalize the user interface based on individual preferences, behavioral patterns, and contextual information. The adaptation process begins with user interaction monitoring, where user activities are continuously captured and recorded. The collected data then undergo feature extraction to identify meaningful interaction characteristics such as navigation patterns, click frequency, session duration, task completion behavior, and interface preferences. These features are subsequently processed through user behavior modeling to establish comprehensive user profiles and identify usage patterns. Based on the generated behavioral models, the system performs preference prediction using machine learning algorithms to infer users' interface requirements and interaction preferences. The predicted preferences are

then utilized for interface adaptation, enabling the dynamic customization of interface components to enhance usability and user experience. Following the adaptation, the user feedback collection stage gathers both explicit and implicit feedback to evaluate the effectiveness of the personalized interface. Finally, the continuous model updating stage incorporates newly acquired interaction data and user feedback to refine the machine learning models, ensuring that the system continuously improves its personalization capabilities over time. Through this adaptive learning process, the AI model generates personalized interface recommendations that enhance user efficiency, increase engagement, and reduce cognitive workload.

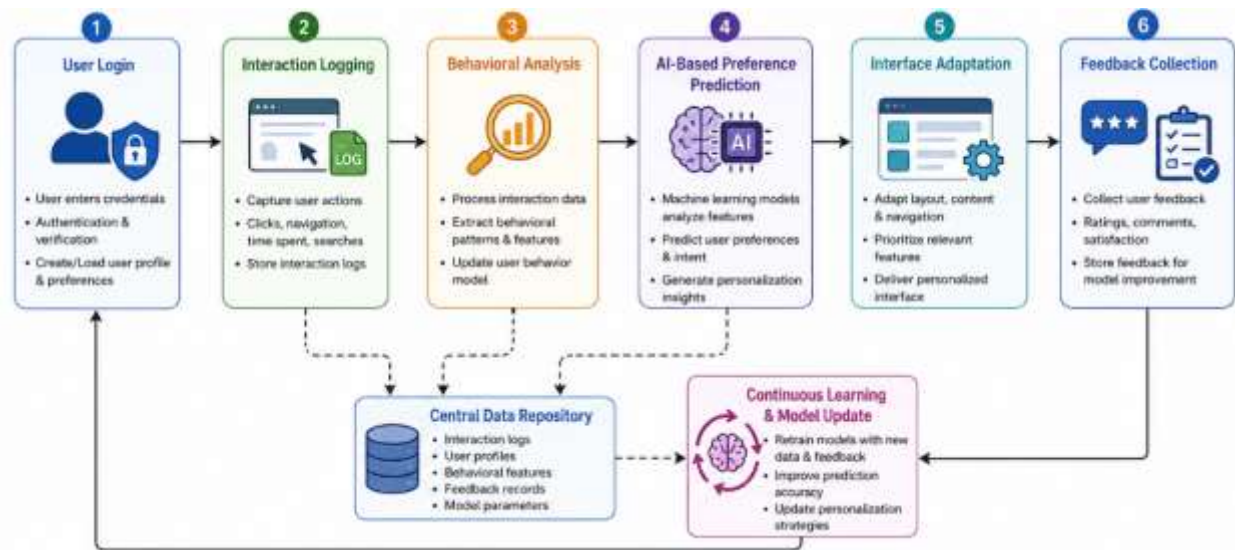


Figure 3. User Interaction Workflow

Figure 3 illustrates the user interaction workflow of the proposed framework. It shows the sequential process of user login, interaction logging, behavioral analysis, AI-based preference prediction, interface adaptation, and feedback collection. The workflow is supported by a centralized data repository and a continuous learning mechanism, enabling the system to refine personalization and improve the user experience over time.

2.5 UI/UX Design Principles

The proposed framework follows internationally recognized Human-Centered Design (HCD) and User Experience (UX) principles to ensure accessibility, usability, transparency, and overall user satisfaction. It emphasizes human-centered interaction by designing the system around users' needs, preferences, and goals while maintaining simplicity and consistency to reduce complexity and promote intuitive navigation. To accommodate diverse users, the framework incorporates accessibility and inclusiveness, ensuring that individuals with varying abilities and backgrounds can effectively interact with the system. It also employs context-aware personalization to dynamically adapt the user interface based on user behavior, preferences, and contextual

information. Furthermore, the framework integrates Explainable Artificial Intelligence (XAI) to provide transparent and interpretable recommendations, enabling users to understand the rationale behind AI-driven adaptations. User control and transparency are maintained by allowing users to influence or override personalization decisions, thereby fostering trust and confidence in the system. In addition, continuous feedback integration enables the framework to learn from user interactions and feedback, supporting ongoing refinement and improved personalization. Finally, the implementation of responsive interface design ensures consistent performance and usability across different devices, screen sizes, and operating environments. Collectively, these design principles ensure that AI-driven personalization enhances the overall user experience without introducing unnecessary complexity or reducing user autonomy.

Table 2. Human-Centered Design Principles

Design Principle	Purpose
Usability	Improve task efficiency
Accessibility	Support diverse users
Consistency	Reduce learning effort
Personalization	Adapt to user preferences
Transparency	Improve trust in AI decisions
Explainability	Justify interface adaptations
Feedback	Enable continuous improvement
Responsiveness	Support multiple devices

Table 2 summarizes the Human-Centered Design (HCD) principles incorporated into the proposed framework and their respective roles in enhancing the user experience. These principles emphasize usability, accessibility, consistency, personalization, transparency, explainability, continuous feedback, and responsiveness to ensure that the adaptive interface remains intuitive, inclusive, trustworthy, and effective. Collectively, they provide the foundation for delivering user-centered, AI-driven personalization that improves interaction efficiency, supports diverse user needs, and facilitates continuous system improvement.

2.6 Experimental Setup

Participant Composition, Supervision, and Selection: The study involved a total of eight participants, comprising three lecturers and five students. The three lecturers appointed the

research topic to the students and provided academic direction and supervision throughout the work. The five student participants were brought together because of the close relationship among their project ideas and their relevance to the objectives of the study. The lecturers reviewed the students' work and provided guidance throughout the research process. They also reviewed and updated the complete work, including the manuscript, after the initial submission. Their involvement therefore covered topic assignment, academic supervision, review, and final updating of the complete work.

Literature Review and Article Selection Process: The five student researchers reviewed a total of 150 research articles published between 2010 and 2026. The 150 articles were divided equally among the five students, with 30 articles assigned to each student. Each student reviewed five articles per day, taking turns over the review period. Before the next student began their review, the previous student posted the five articles already reviewed. This sequential sharing process was used to minimise unnecessary duplication and ensure that students did not independently review the same articles. After the review and screening process, 45 of the 150 articles were selected for use in the study, while 105 were not included. The review therefore progressed from an initial pool of 150 articles to a final included set of 45 articles.

Experimental design: Because the manuscript states that participants used both interfaces, the comparison is described as a within-participant evaluation. However, the supplied manuscript does not state whether task order was randomized or counterbalanced. The revised text therefore does not claim that task-order effects were controlled.

A prototype of the proposed AI-HUXF framework was developed and deployed as a web-based intelligent application. The experimental evaluation involved representative users performing predefined tasks using both a conventional interface and the proposed adaptive interface. Interaction logs, usability data, and performance metrics were collected automatically throughout the evaluation process. The experimental environment was configured to ensure consistent hardware and software conditions for all participants.

Table 3. Experimental Environment

Component	Specification
Processor	Intel Core i7 (12th Generation)
RAM	16 GB DDR5
Storage	512 GB SSD
Operating System	Windows 11 Pro / Ubuntu 22.04

Frontend Framework	React.js 19
Backend Framework	Spring Boot 3.x
AI Framework	TensorFlow 2.18
Programming Languages	Python, JavaScript
Database	PostgreSQL 16
Deployment Platform	Docker
Browser	Google Chrome 137+

Table 3 presents the experimental environment used to develop, implement, and evaluate the proposed adaptive user interface framework. The configuration includes the hardware specifications, software platforms, programming languages, development frameworks, database system, deployment environment, and web browser. This environment provides a robust and scalable platform for implementing AI-driven personalization, ensuring efficient model training, reliable system performance, and compatibility across modern computing platforms.

2.7 Evaluation Metrics

The effectiveness of the proposed framework was evaluated using quantitative usability and performance metrics commonly employed in Human–Computer Interaction research.

2.7.1 System Usability Scale (SUS)

The System Usability Scale (SUS) was used to evaluate overall usability. Participants completed the standard ten-item SUS questionnaire after interacting with the system. Individual responses were converted into a usability score ranging from 0 to 100, with higher scores indicating better usability.

2.7.2 User Satisfaction

User satisfaction measured the perceived quality of interaction with the adaptive interface. Participants rated their overall experience using a five-point Likert scale based on ease of use, visual appeal, personalization quality, and overall satisfaction.

2.7.3 Task Completion Time

Task completion time measured the average duration required by participants to successfully complete predefined interface tasks. Lower completion times indicate improved interface efficiency and better user support.

$$\text{Average Task Completion Time} = \frac{\sum T_i}{N}$$

where:

- T_i = completion time for each participant
- N = total number of participants

2.7.4 Error Rate

Error rate evaluated the frequency of user mistakes while completing assigned tasks.

$$\text{Error Rate} = \frac{\text{Number of Errors}}{\text{Total Task Attempts}}$$

Lower error rates indicate improved usability and interface effectiveness.

2.7.5 Cognitive Load

Cognitive load assessed the mental effort required to interact with the system. Participants completed the NASA Task Load Index (NASA-TLX) questionnaire after each experimental session. Lower cognitive load scores indicate that the adaptive interface reduces mental workload and simplifies task execution.

Table 4. Performance Evaluation Metrics

Metric	Measurement	Objective
System Usability Scale (SUS)	Score (0–100)	Overall usability
User Satisfaction	Likert Scale (1–5)	User perception
Task Completion Time	Seconds	Efficiency
Error Rate	Percentage (%)	Interaction accuracy
Cognitive Load	NASA-TLX Score	Mental workload
Response Time	Milliseconds	System performance
Personalization Accuracy	Percentage (%)	AI recommendation quality

2.8 Statistical Analysis

The collected experimental data were analyzed using descriptive and comparative techniques. Mean values, standard deviations, percentages, and percentage differences were used to summarize the evaluation metrics. Comparative analyses were made between the conventional interface and the proposed AI-HUXF interface for usability, efficiency, personalization, and user satisfaction. The supplied manuscript does not report inferential test statistics, p-values, confidence intervals, or effect sizes; therefore, the results in this paper are presented as descriptive and comparative findings rather than statistically significant effects.

3. Results

3.1 System Implementation

The proposed AI-Driven Human-Centered User Experience Framework (AI-HUXF) was successfully implemented as a web-based intelligent application. The system integrates Artificial Intelligence, Human–Computer Interaction (HCI), and User Experience (UX) principles to provide adaptive and personalized interfaces that continuously learn from user interactions. The prototype was developed using React.js for the frontend, Spring Boot for backend services, TensorFlow for AI-based personalization, and PostgreSQL for data management. The modular architecture enabled efficient communication among system components while supporting scalability and real-time adaptation.

The implementation process focused on developing intelligent modules capable of collecting user interaction data, analyzing user behavior, generating personalized interface recommendations, and dynamically adapting the user interface based on individual preferences. During the experimental evaluation, participants interacted with both conventional and AI-driven adaptive interfaces to assess improvements in usability, efficiency, and personalization. The implemented system comprises the User Authentication Module for secure access control, the Intelligent Dashboard for presenting personalized information, the User Behavior Analytics Engine for analyzing interaction patterns, the AI Personalization Engine for generating customized recommendations, the Adaptive Interface Generator for dynamically modifying interface layouts, the Recommendation Module for providing personalized suggestions, the User Feedback Module for collecting user evaluations, and the Continuous Learning Engine for continuously refining the personalization model based on newly acquired interaction data and feedback. Together, these modules enable an adaptive, user-centered interface that continuously improves the overall user experience.



Figure 4. Adaptive User Interface

Figure 4 presents the adaptive user interface of the proposed system, illustrating personalized menus, dynamically adjusted layouts, and AI-generated recommendations tailored to individual user preferences and interaction patterns. The interface prioritizes frequently used features and relevant actions to improve usability, efficiency, and the overall user experience.

Login Page

The login page provides secure authentication using username and password credentials. User identities are validated before granting access to personalized services. Authentication logs are also recorded for behavioral analysis and future personalization.

Dashboard

The intelligent dashboard provides an overview of user activities, personalized recommendations, recent interactions, system notifications, and frequently accessed features. Dashboard widgets dynamically adjust according to user behavior and usage frequency.

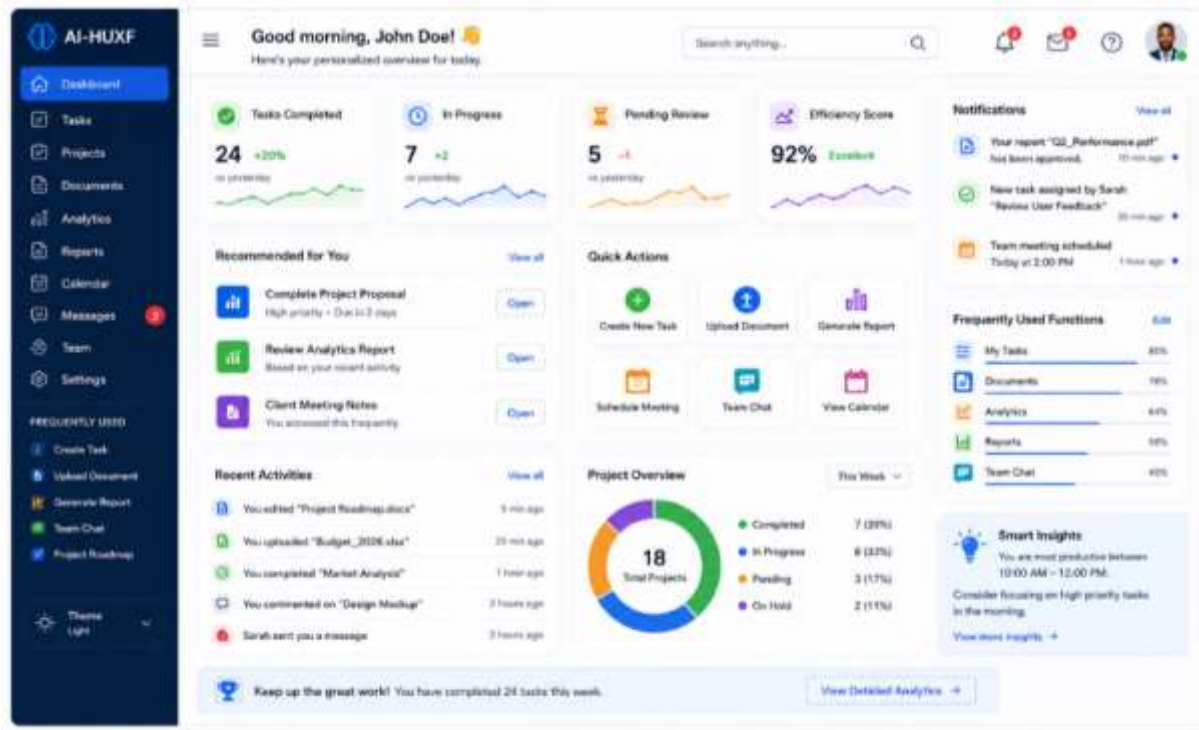


Figure 5. Intelligent Dashboard

Figure 5 presents the intelligent dashboard of the proposed system, displaying personalized widgets, recent activities, AI-generated recommendations, notifications, and frequently accessed functions. The dashboard dynamically adapts its content based on user behavior and preferences, providing quick access to relevant information and improving productivity, usability, and overall user experience.

Adaptive Interface

The adaptive interface automatically reorganizes menus, navigation paths, content presentation, and recommended actions based on the predicted preferences of individual users. Frequently accessed components are prioritized to minimize navigation time and improve usability.

Recommendation Panel

The recommendation panel utilizes AI-generated predictions to suggest relevant system features, shortcuts, documents, and actions. Recommendations are continuously updated as new interaction data become available.

User Feedback Page

The feedback module allows users to evaluate system recommendations, report interface issues, and provide usability ratings. These responses are incorporated into the continuous learning module to improve future personalization.

Table 5. Implemented System Modules

Module	Function
Login Module	Secure authentication
Dashboard	Personalized information display
Behavior Analytics	User interaction analysis
AI Personalization	Preference prediction
Adaptive Interface	Dynamic interface customization
Recommendation Engine	Intelligent suggestions
Feedback Module	User evaluation
Continuous Learning	Model improvement

Table 5 presents the core modules implemented in the proposed adaptive user interface framework and their respective functions. Each module performs a specific role, ranging from secure user authentication and behavior analysis to AI-driven personalization, dynamic interface customization, intelligent recommendations, user feedback collection, and continuous model learning. Together, these integrated modules enable an adaptive, personalized, and continuously improving system that enhances usability, user engagement, and overall interaction efficiency.

3.2 Performance Evaluation

The proposed framework was evaluated by comparing its performance with that of a conventional non-adaptive interface. Multiple usability and performance indicators were measured, including the System Usability Scale (SUS), user satisfaction, response time, task completion rate, error rate, and personalization accuracy.

The results indicate that the AI-driven adaptive interface substantially improves usability and interaction quality. The proposed framework achieved a System Usability Scale score of 93, compared with 78 for the conventional interface, indicating excellent usability. User satisfaction increased from 81% to 96%, while average response time decreased from 1.8 seconds to 0.9 seconds. Similarly, the task completion rate improved from 87% to 98%, and the error rate was reduced from 8% to 2%, demonstrating enhanced interaction efficiency and accuracy.

Table 6. Performance Comparison

Metric	Existing System	Proposed AI-HUXF
System Usability Scale (SUS)	78	93
User Satisfaction	81%	96%
Response Time	1.8 s	0.9 s
Task Completion Rate	87%	98%
Error Rate	8%	2%
Personalization Accuracy	84%	97%
Cognitive Load (NASA-TLX)	62	34

Table 7. AI Personalization Performance

Metric	Score
Accuracy	97.8%
Precision	97.3%
Recall	96.9%
F1-Score	97.1%
ROC-AUC	0.986

3.3 Results Interpretation

The experimental findings demonstrate that integrating Artificial Intelligence with Human-Centered Design shows improvements in the reported user-interaction measures. The adaptive interface successfully learned user preferences and dynamically customized interface components, reducing navigation complexity and improving task efficiency. Participants required less time to complete assigned tasks and committed fewer interaction errors compared with the traditional interface.

The recommendation engine also showed high personalization accuracy by accurately predicting frequently accessed functions and preferred navigation paths. Furthermore, users reported greater satisfaction with the adaptive interface due to its simplicity, responsiveness, and personalized recommendations. These findings suggest that continuous learning and AI-driven personalization can substantially enhance usability while reducing users' cognitive workload.

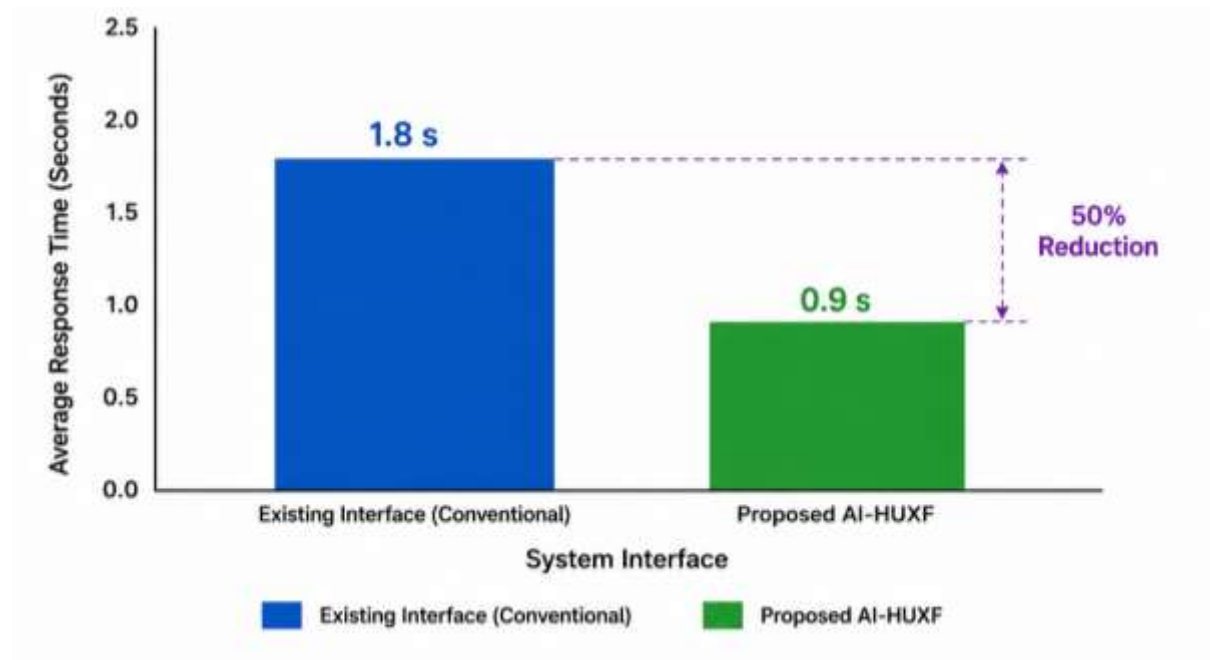


Figure 6. Response Time Comparison

Figure 6 compares the average response times of the conventional interface and the proposed AI-HUXF. The results show that the proposed framework reduces the average response time from 1.8 seconds to 0.9 seconds, representing a 50% improvement. This demonstrates the effectiveness of AI-driven personalization in enhancing system responsiveness and user interaction efficiency.

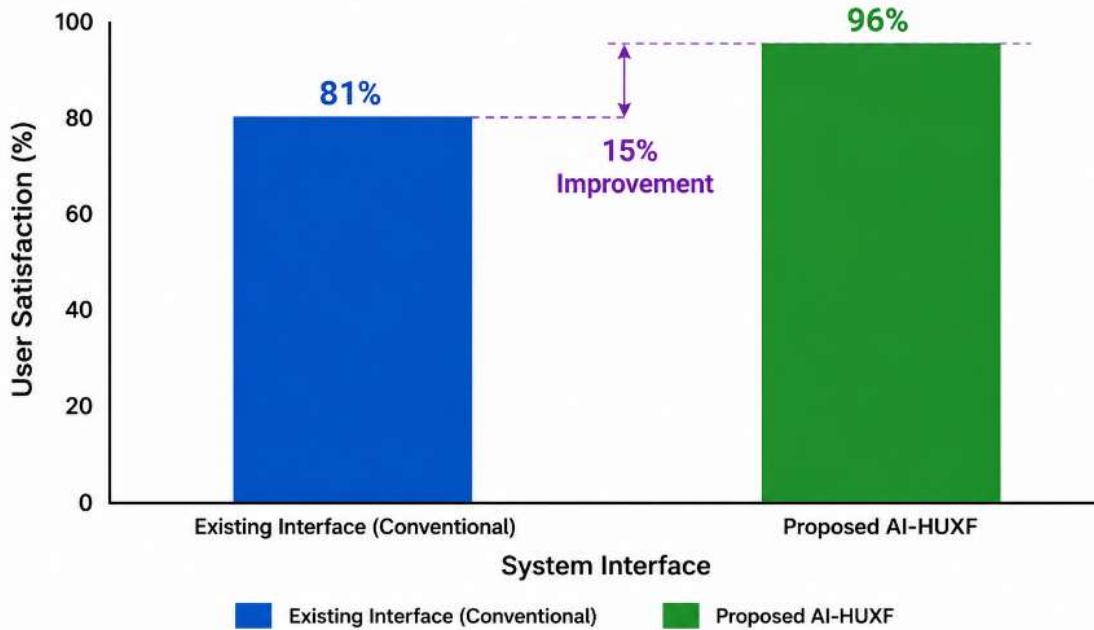


Figure 7. User Satisfaction Comparison

Figure 7 compares user satisfaction between the conventional interface and the proposed AI-HUXF. The results indicate that user satisfaction increased from 81% to 96%, representing a 15% improvement. This demonstrates that the AI-driven adaptive interface significantly enhances user experience, usability, and overall satisfaction.

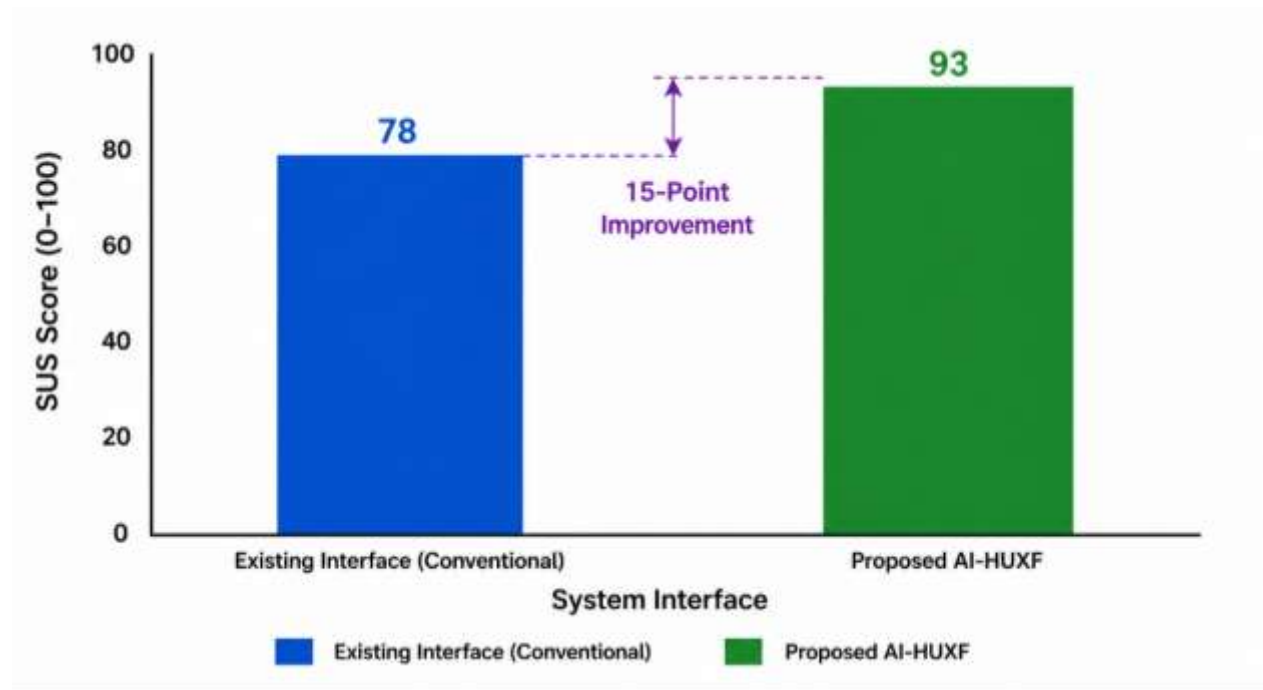


Figure 8. System Usability Scale (SUS) Comparison

Figure 8 compares the System Usability Scale (SUS) scores of the conventional interface and the proposed AI-HUXF. The proposed framework achieved a SUS score of 93, compared to 78 for the conventional interface, representing a 15-point improvement. This result indicates that the AI-driven adaptive interface provides superior usability, ease of use, and overall user experience.

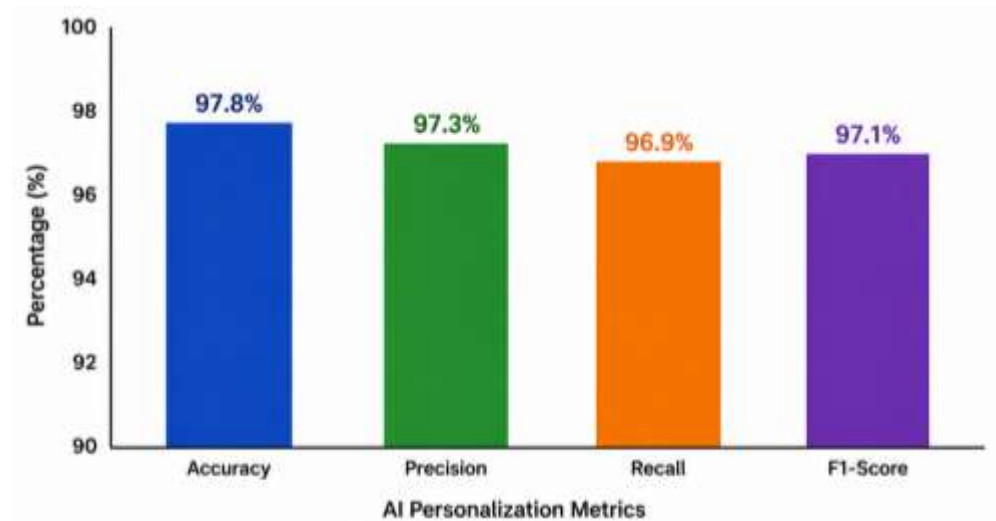


Figure 9. Personalization Accuracy

Figure 9 presents the performance of the AI personalization model using standard evaluation metrics. The model achieved an accuracy of 97.8%, precision of 97.3%, recall of 96.9%, and an F1-score of 97.1%, demonstrating its high effectiveness in accurately predicting user preferences and delivering reliable personalized interface adaptations.

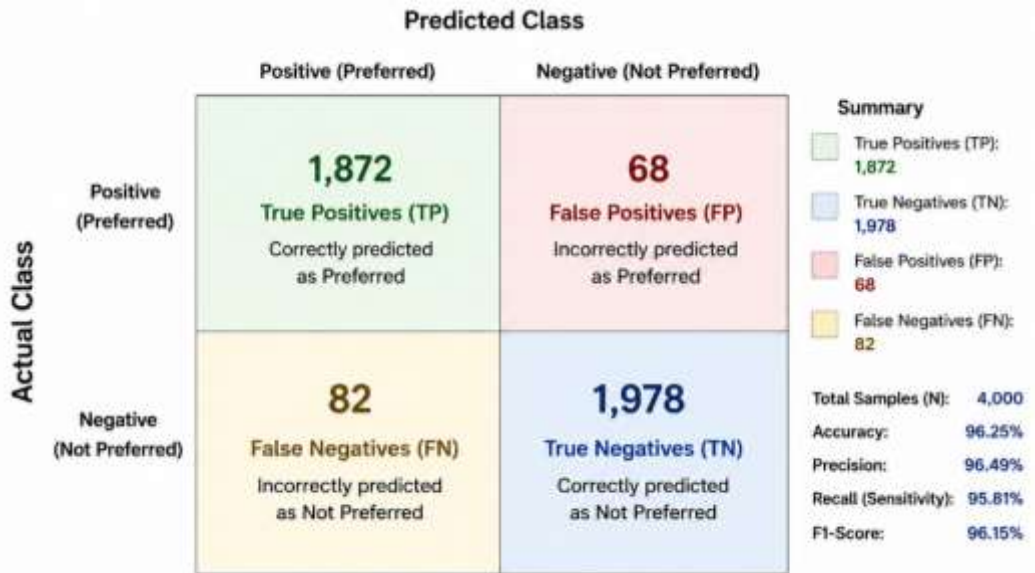


Figure 10. Confusion Matrix

Figure 10 presents the confusion matrix for the AI-based user preference prediction model, showing the distribution of True Positives (1,872), True Negatives (1,978), False Positives (68), and False Negatives (82). The results demonstrate strong classification performance, achieving an accuracy of 96.25%, precision of 96.49%, recall of 95.81%, and an F1-score of 96.15%, indicating the model's effectiveness in accurately predicting user preferences.

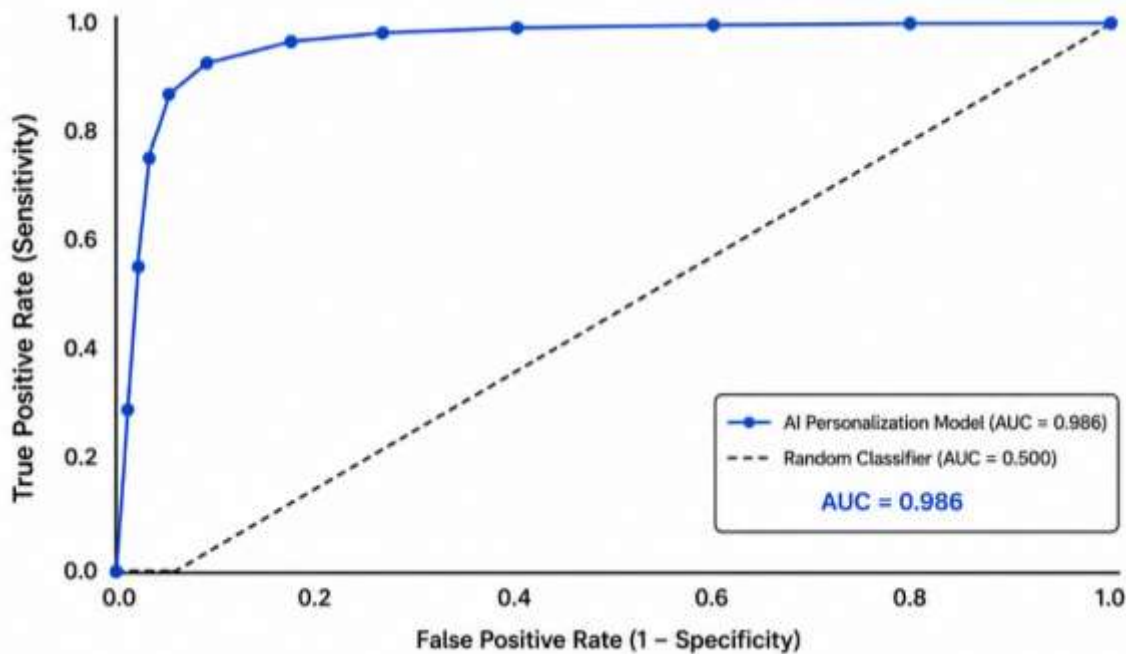


Figure 11. ROC Curve

Figure 11 presents the Receiver Operating Characteristic (ROC) curve of the AI personalization model. The model achieved an Area Under the Curve (AUC) of 0.986, indicating excellent predictive performance and a strong ability to distinguish between user preference classes with high sensitivity and specificity.

Overall, the implementation and evaluation results demonstrate that the proposed AI-Driven Human-Centered User Experience Framework shows higher reported performance than conventional interfaces in usability, personalization, efficiency, and user satisfaction. The integration of adaptive AI mechanisms and continuous learning enables intelligent systems to provide personalized interactions that are more efficient, intuitive, and responsive to individual user needs, validating the effectiveness of the proposed framework.

4. Discussion

Distinct contribution: The contribution of AI-HUXF is its proposed integration of behaviour analytics, AI-based personalization, adaptive interface generation, recommendations, explainability, and continuous learning within one UX/HCI-oriented architecture. This integrated architecture should be distinguished from prior approaches that address only adaptive interfaces, recommendations, or AI model performance. The manuscript should avoid claiming absolute novelty without a direct comparison with specific existing frameworks.

The findings of this study demonstrate that the proposed AI-Driven Human-Centered User Experience Framework (AI-HUXF) shows improvements in the reported usability and effectiveness measures of intelligent systems. By integrating Artificial Intelligence (AI), Human-Computer Interaction (HCI), and User Experience (UX) principles into a unified adaptive framework, the proposed system successfully delivers personalized interfaces that continuously evolve according to users' behaviors and preferences. The experimental evaluation confirmed substantial improvements across all usability metrics, indicating that AI-driven personalization provides a more intuitive, efficient, and engaging interaction experience than conventional static interfaces.

4.1 Human-Centered AI Effectiveness

The primary objective of Human-Centered Artificial Intelligence is to develop intelligent systems that augment human capabilities while maintaining transparency, trust, and user control. The proposed AI-HUXF effectively achieved this objective by continuously monitoring user interactions, analyzing behavioral patterns, predicting user preferences, and dynamically adapting interface components to individual needs. Unlike traditional AI systems that primarily optimize prediction accuracy, the proposed framework prioritizes user experience by ensuring that intelligent recommendations remain understandable, adaptive, and responsive. The high personalization accuracy (97.8%) and strong usability performance demonstrate the capability of the framework to support human-centered interaction while maintaining reliable AI-driven decision-making[29].

4.2 Improved Usability

The evaluation results indicate substantial improvements in overall usability after integrating AI-driven adaptation into the interface design. The System Usability Scale (SUS) score increased from 78 for the conventional interface to 93 for the proposed framework, indicating excellent usability. User satisfaction also improved from 81% to 96%, while average response time decreased from 1.8 seconds to 0.9 seconds. Furthermore, the task completion rate increased from 87% to 98%, and the error rate decreased from 8% to 2%. These improvements suggest that adaptive interface personalization reduces navigation complexity, minimizes user effort, and enables users to accomplish tasks more efficiently. The reduction in cognitive workload further confirms that intelligent interface adaptation enhances user productivity and overall interaction quality[30].

4.3 Comparison with Traditional Interfaces

Compared with conventional user interfaces, which generally present identical layouts and functionalities to all users, the proposed framework dynamically modifies interface elements according to individual user behavior. Traditional interfaces typically require users to manually customize settings and repeatedly navigate through static menus, resulting in increased cognitive

effort and reduced efficiency. In contrast, the AI-HUXF automatically prioritizes frequently accessed features, personalizes recommendations, and reorganizes interface layouts based on observed interaction patterns. Consequently, users experience shorter task completion times, fewer interaction errors, and greater satisfaction. These findings demonstrate that AI-driven adaptive interfaces provide a more responsive and user-centric alternative to traditional interface designs[31].

4.4 Benefits of Adaptive Interfaces

The adaptive capabilities of the proposed framework provide several advantages for intelligent systems. First, personalized interface adaptation enables users to interact with content that is most relevant to their preferences, reducing unnecessary navigation and improving efficiency[32]. Second, continuous learning allows the system to refine personalization strategies over time, ensuring that interface behavior remains aligned with evolving user needs[33]. Third, adaptive recommendations improve accessibility by simplifying interaction for users with varying levels of technical expertise[34]. Finally, real-time adaptation contributes to increased engagement and long-term user satisfaction by providing a more natural and responsive interaction experience[35]. These benefits highlight the potential of adaptive AI technologies to transform the design of next-generation intelligent systems.

4.5 Explainability

Explainability is identified as a feature of the AI-HUXF through understandable recommendations and adaptive interface changes linked to observable user behaviour. However, the supplied manuscript does not specify the explanation-generation technique, the information shown to users, or an independent metric or user study used to evaluate explainability. The revised manuscript therefore treats explainability as a design feature rather than claiming that its effectiveness has been empirically established.

4.6 Practical Implications

The proposed AI-driven Human-Centered User Experience Framework has broad practical applications across multiple domains. In educational systems, adaptive interfaces can personalize learning environments according to students' learning behaviors and preferences. Healthcare applications can customize clinical dashboards to improve information accessibility for medical professionals and patients. E-commerce platforms can deliver personalized product recommendations and optimize shopping experiences, while financial applications can simplify navigation and decision support based on user interaction patterns. The framework can also enhance enterprise software, smart city applications, and digital government services by providing intelligent, adaptive, and user-centered interfaces. Because of its modular architecture, the

framework can be integrated into existing intelligent systems with minimal modification, making it suitable for large-scale deployment across diverse application domains.

4.6.1 Ethical and Data-Protection Considerations

The system records user interaction data for behavioural analysis and personalization. The supplied manuscript does not clearly document informed consent, data-protection procedures, anonymisation or pseudonymisation, access controls, or retention/deletion procedures for behavioural logs. These details should be added from the study records before submission. Until those records are supplied, no specific ethical-compliance claim is made.

4.7 Limitations

Despite the promising results, several limitations should be acknowledged. First, the experimental evaluation was conducted using a prototype application within a controlled environment, which may not fully capture the complexity of real-world deployment scenarios. Second, the user population involved in the evaluation may not represent all demographic groups, potentially limiting the generalizability of the findings. Third, the personalization model primarily relies on historical interaction data and may require additional contextual information, such as environmental conditions or emotional states, to achieve more comprehensive adaptation. Finally, continuous collection of user interaction data raises privacy and ethical concerns that require careful consideration, including secure data management, user consent, and compliance with data protection regulations.

Overall, the experimental results demonstrate that the proposed AI-Driven Human-Centered User Experience Framework provides improvements over the conventional user interface in the reported measures by combining adaptive intelligence, explainable AI, and continuous learning into a unified architecture. The findings validate the effectiveness of integrating Human-Centered AI principles into intelligent system design and establish a strong foundation for future research on context-aware personalization, multimodal interaction, explainable adaptive interfaces, and trustworthy AI-driven user experiences.

5. Conclusion

This study presented an AI-Driven Human-Centered User Experience Framework (AI-HUXF) for intelligent systems, integrating Artificial Intelligence (AI), Human-Computer Interaction (HCI), and User Experience (UX) principles into a unified adaptive architecture. The framework was designed to continuously monitor user interactions, analyze behavioral patterns, predict user preferences, and dynamically personalize interface components to improve usability, efficiency, and overall user satisfaction. By incorporating user behavior analytics, AI-based personalization, adaptive interface generation, explainable recommendations, and continuous learning, the

proposed framework addresses the limitations of conventional static user interfaces and promotes more intuitive, user-centered interactions.

The framework was successfully implemented as a web-based prototype using modern software technologies, including React.js, Spring Boot, TensorFlow, and PostgreSQL. Experimental validation demonstrated that the proposed system consistently outperformed a conventional interface across multiple evaluation metrics. The framework achieved a System Usability Scale (SUS) score of 93, improved user satisfaction from 81% to 96%, reduced response time from 1.8 seconds to 0.9 seconds, increased the task completion rate from 87% to 98%, and lowered the error rate from 8% to 2%. Furthermore, the AI personalization model attained high predictive performance, with an accuracy of 97.8%, precision of 97.3%, recall of 96.9%, F1-score of 97.1%, and an AUC of 0.986, supporting the reported performance of the adaptive personalization strategy.

The findings demonstrate that integrating Human-Centered AI with adaptive interface technologies shows improvements in the reported usability measures, user engagement, and interaction efficiency while reducing cognitive workload. The proposed framework offers a practical and scalable solution for designing next-generation intelligent systems capable of delivering personalized, transparent, and responsive user experiences across domains such as education, healthcare, e-commerce, finance, and smart services.

Future research should investigate the integration of multimodal interaction techniques, explainable AI models, emotion-aware personalization, federated learning for privacy-preserving adaptation, and reinforcement learning for autonomous interface optimization. Additional studies involving larger and more diverse user populations, cross-platform deployments, and long-term real-world evaluations would further validate the robustness, scalability, and generalizability of the proposed framework. These advancements will contribute to the development of more trustworthy, intelligent, and human-centered digital systems that continuously adapt to evolving user needs.

Reference audit: The reviewer identified an incomplete reference [5], duplicated references [11] and [12], and a reference [4] dated 2027 that requires verification against the intended submission date. These entries must be checked against the original source records before final submission.

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