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A Web-Based Forward-Chaining Expert System for Smartphone Selection: A Decision Support Tool for Novice

Daffa Ihsan Al Hakim
Batam Institute of Technology, INDONESIA

Lucky Edward
Batam Institute of Technology, INDONESIA

Muhammad Fitrizhika
Batam Institute of Technology, INDONESIA

Deosa Putra Caniago*
Batam Institute of Technology, INDONESIA

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Abstract

Background: The rapid growth of smartphone technology presents users, particularly novices, with an overwhelming array of specifications, brands, and price points. Many beginners lack the technical understanding required to make informed purchasing decisions, often leading to mismatches between device features and user needs.
Objective: This study aims to design and implement a web-based expert system that assists novice users in selecting smartphones tailored to their specific preferences and requirements.
Methods: The system applies the forward chaining inference method to a knowledge base composed of IF–THEN rules. Users input initial facts through a guided questionnaire covering aspects such as intended usage, budget range, and technical preferences. These inputs are processed through an inference engine to generate personalized smartphone recommendations.
Result: Testing demonstrates that the system can accurately provide smartphone suggestions aligned with user needs. The interface is intuitive and suitable for non-technical users, helping them navigate complex purchase decisions with confidence.
Conclusion: The forward chaining expert system proves effective as a user-centric decision support tool, simplifying smartphone selection for beginners. Its modular design and rule-based logic also make it adaptable for other recommendation domains in consumer electronics.

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INTRODUCTION

The evolution of smartphone technology in the last decade has been both rapid and multidimensional, involving advancements in processing power, camera systems, battery efficiency, display quality, and connectivity (Dachawar et al. 2025 Pan, Y., & Yang, B. 2024); . This explosion in innovation has resulted in a highly competitive market filled with diverse models released annually by global and local manufacturers (Sitompul & Anwar, 2023). While this abundance of choice benefits consumers with a wide range of alternatives, it simultaneously increases decision complexity, particularly for novice users who lack sufficient technical literacy to interpret specification sheets or evaluate the practical impact of smartphone features (Prihantini, Manggabarani, & Wikantari, 2024). In the absence of expert guidance, users are at risk of selecting devices that are either over-specified—leading to inefficient budget allocation—or under-specified, resulting in suboptimal performance and dissatisfaction (Amperawansyah & Putri, 2022). These challenges highlight the necessity for intelligent decision-support mechanisms capable of translating user needs into actionable product recommendations (Saad et al., 2025)

To address decision complexity in technology selection, prior studies have demonstrated the effectiveness of decision support systems (DSS) and expert systems in various domains. Sitompul and Anwar (2023), for instance, implemented the Simple Multi Attribute Rating Technique (SMART) to rank smartphone alternatives based on weighted criteria. Meanwhile, expert systems employing forward chaining inference mechanisms have been shown to perform reliably in diagnostic and recommendation contexts, particularly when combined with certainty-based reasoning models.

*** Corresponding author:**
Deosa Putra Caniago, Batam Institute of Technology, INDONESIA. deosa@iteba.ac.id

Research by Caniago and Sumijan (2020) demonstrated that integrating forward chaining with the Certainty Factor (CF) method significantly improves reasoning accuracy in diagnosing infectious skin diseases. Similar methodological robustness has been validated in expert system applications for otitis diagnosis (Jufri & Caniago, 2022) and anosmia disease identification (Caniago & Masril, 2022), underscoring the adaptability and consistency of rule-based inference approaches across health-related decision problems.

Beyond the medical domain, expert systems using forward chaining and CF have been successfully extended to consumer-oriented recommendation systems. Caniago et al. (2024) applied these methods to develop a web-based expert system for recommending four-star hotels in Batam City, demonstrating that rule-based reasoning can effectively capture user preferences and convert them into personalized recommendations without requiring technical expertise from users. This finding aligns with broader expert system research in medical diagnostics (Sari, Defit, & Nurcahyo, 2020), psychological assessment (Larasaty & Prasetyaningrum, 2024), and dental health analysis (Yansyah & Sumijan, 2021), where structured IF–THEN rules combined with inference engines consistently yield accurate and user-friendly decision outcomes. Furthermore, web-based deployment of expert systems has been found to enhance system accessibility, usability, and real-time interaction, making such systems suitable for large-scale public use (Setiawan et al., 2023).

Despite these developments, many existing DSS and expert system implementations remain oriented toward professional or technical users, assuming familiarity with quantitative metrics or structured input parameters(Remus & Kotteman, 1986; Seymoens et al., 2018). Such assumptions limit system usability for everyday consumers, particularly first-time smartphone buyers or users with limited technical backgrounds (Sandy & Paramita, 2025). While forward chaining has proven effective in structured diagnostic reasoning (Caniago & Sumijan, 2020; Caniago & Masril, 2022; Jufri & Caniago, 2022), its application in user-centric, consumer-facing recommendation systems for smartphone selection remains relatively unexplored. There is also a notable lack of intuitive web-based platforms that leverage expert reasoning models to bridge the gap between subjective user preferences and complex technical specifications (Ardissono et al., 2002; Pommeranz et al., 2012).

This study is motivated by the need to democratize access to expert-level guidance in smartphone purchasing decisions by eliminating dependence on technical knowledge(Geetha & Sam, 2025; Varun & R, 2025). Building upon prior work demonstrating the reliability of forward chaining and certainty factor integration in decision systems (Caniago & Sumijan, 2020; Caniago et al., 2024), this research proposes a web-based expert system that interprets natural user preferences—such as gaming performance, photography needs, multitasking capability, battery endurance, and budget constraints—and translates them into structured inference rules. By applying forward chaining reasoning, the system incrementally derives conclusions that align user needs with suitable smartphone alternatives, ensuring transparency and logical consistency in the recommendation process (Setiawan et al., 2023).

The primary objective of this research is to design and implement a forward chaining–based expert system in a web environment that assists novice users in selecting smartphones tailored to their individual requirements. The system aims to simplify the decision-making process by converting user inputs into logical conclusions through a structured knowledge base and inference engine, ultimately producing clear and actionable recommendations. In addition to providing practical benefits for consumers, this study seeks to extend the application of expert systems beyond traditional diagnostic domains into personal electronics decision-making. The modular and rule-based architecture of the proposed system also enables future expansion, allowing the framework to be adapted to other recommendation domains such as laptops, wearable devices, or smart home products.

METHOD

Research Design

This study employs a rule-based system development approach to create a web-based expert system that recommends smartphones to novice users. The inference engine applies the forward chaining method, enabling the system to start from known facts (user preferences) and derive conclusions (smartphone recommendations) by evaluating logical rules. The development followed the Waterfall model, which includes stages of requirement analysis, system design, implementation, and testing.

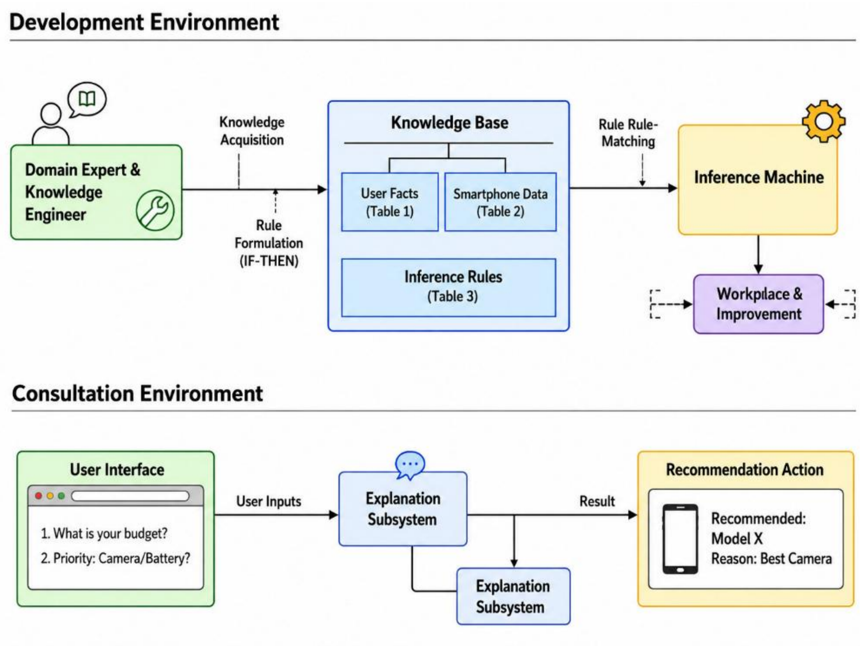

Figure 1. System Architecture of the Expert System

Participant

Participants were simulated based on beginner smartphone user personas. These included user types such as students, content creators, casual users, and working professionals with limited technical knowledge. No real human subjects were directly involved in testing, but use cases were modeled on common user behavior gathered from literature and market data.

Population and the Methods of Sampling Instrumentation

The target population comprises general Indonesian users with low-to-moderate digital literacy seeking to purchase smartphones in 2025. The sampling approach was purposive and literature-based, using secondary sources and smartphone usage trends to construct realistic test profiles. Data collection included structured need-based profiling and extraction of user goals such as gaming, photography, and content creation. The system design incorporated 17 user facts derived from these preferences, shown in Table 1.

Table 1. User Facts

Code	User Fact Description
A1	Professional camera for photography
A2	Camera for 4K video recording
A3	Playing heavy mobile games
A4	Running multiple heavy applications
A5	Used for professional work
A6	Creating short content for social media
A7	Requires aesthetic design
A8	High screen refresh rate
A9	Large battery capacity
A10	Uses Android operating system
A11	Uses Apple operating system
A12	Has a high budget
A13	Has a mid-range budget
A14	Has a low budget
A15	Requires large storage capacity
A16	Requires water and dust resistance
A17	Needs additional or exclusive features

Instrument

The primary instrument is the expert system itself, which was developed using HTML and JavaScript for the interface and inference logic. It includes; A knowledge base of 17 user facts and 12 smartphone alternatives (see Table 2), A rule base of 12 IF–THEN inference rules (see Table 3), A forward chaining inference engine, A user interface that allows fact selection and displays output with brief explanations.

Table 2. Smartphone Alternatives

Code	Smartphone Model
P1	Realme C65
P2	Oppo A6 Pro
P3	Vivo Y200e
P4	Redmi Note 13 Pro+
P5	POCO F7
P6	OnePlus 12
P7	Xiaomi 14
P8	Google Pixel 10 Pro
P9	Asus ROG Phone 8
P10	iPhone 16 Pro
P11	Samsung Galaxy S25 Ultra
P12	Xiaomi 14 Ultra

Table 3. Inference Rules

Rule	IF (User Facts)	THEN (Recommended Smartphone)
R1	*A14 AND A9*	P1 (Realme C65)
R2	*A6 AND A13*	P2 (Oppo A6 Pro)
R3	*A6 AND A8*	P3 (Vivo Y200e)
R4	*A3 AND A13*	P4 (Redmi Note 13 Pro+)
R5	*A3 AND A9*	P5 (POCO F7)
R6	*A4 AND A12*	P6 (OnePlus 12)
R7	*A4 AND A15*	P7 (Xiaomi 14)
R8	*A1 AND A2 AND A10 AND A12*	P8 (Google Pixel 10 Pro)
R9	*A3 AND A7 AND A9 AND A10 AND A12 AND A15*	P9 (Asus ROG Phone 8)
R10	*A1 AND A2 AND A11 AND A12*	P10 (iPhone 16 Pro)
R11	*A1 AND A2 AND A7 AND A10*	P11 (Samsung Galaxy S25 Ultra)
R12	*A1 AND A2 AND A10 AND A15*	P12 (Xiaomi 14 Ultra)

Procedures and Time Frame

System development was conducted over a three-month period from March to May 2025. The stages included; Requirement Analysis – identification of user preferences and system objectives, Knowledge Acquisition – formulation of user facts, smartphone data, and logical rules, System Design – architecture, interface layout, and rule mapping strategy, Implementation – coding the front-end and back-end logic, Testing and Evaluation – validating rule activation and recommendation outputs using simulated test cases.

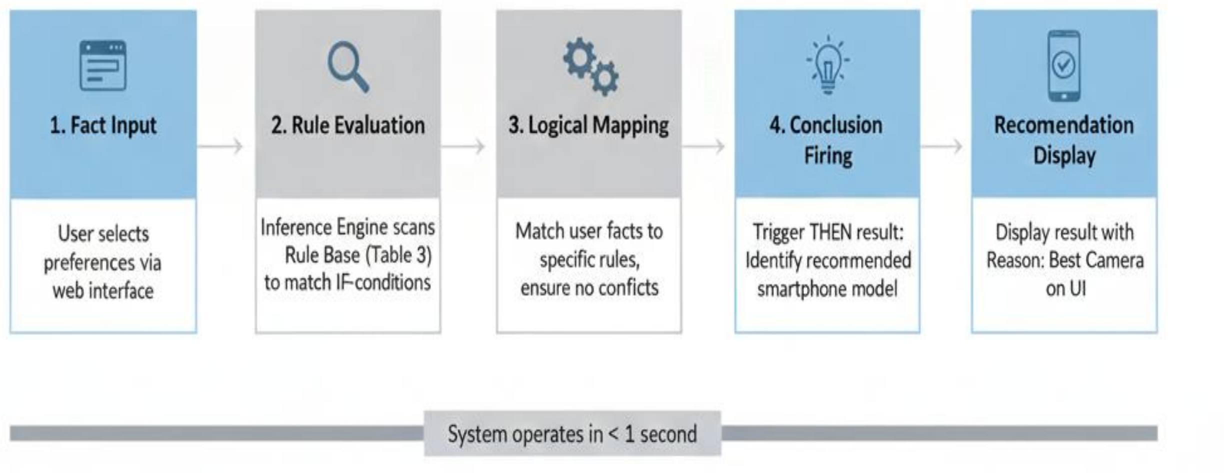

Figure 2. Forward Chaining Inference Process Flow

To visualize how user preferences are mapped logically to smartphone options through a rule-based structure, the system provides an overall logical mapping layout.

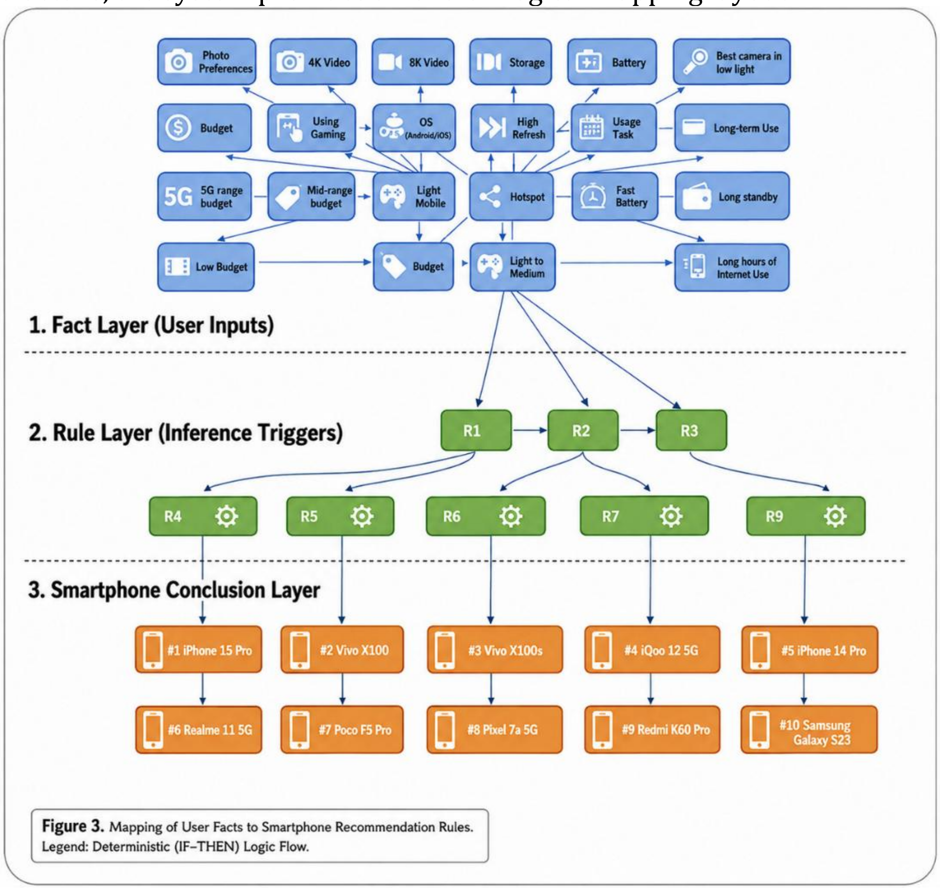

Figure 3. Mapping of User Facts to Smartphone Recommendation Rules

To ensure usability, the interface was designed with simplicity in mind. Users can check preferences, submit their input, and receive a recommendation with reasoning.

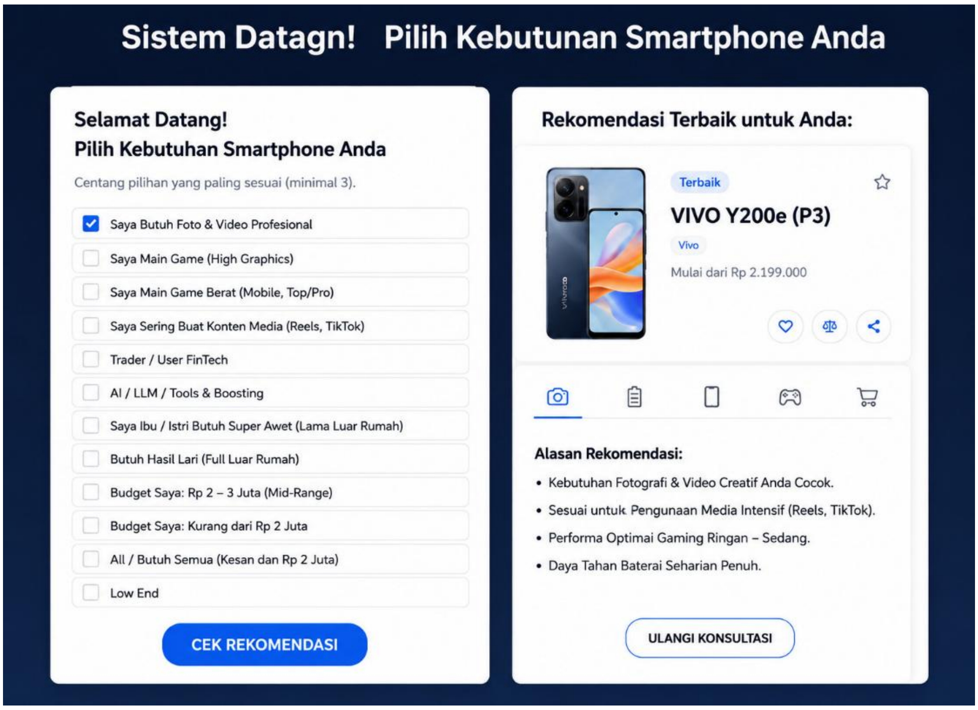

Figure 4. User Interface: Fact Selection and Recommendation Result

Analysis Plan

The system was tested using structured test cases designed to trigger specific rules. Outputs were reviewed to ensure; Logical accuracy (correct recommendation triggered), Response time (system responsiveness), Usability (ease of use and clarity, verified via heuristic evaluation). Descriptive methods were used to analyze system behavior across multiple input scenarios. No statistical analysis was required due to the rule-based deterministic nature of the system.

Scope and Limitation

The system currently supports only 12 smartphone recommendations and does not integrate live pricing or dynamic updates. It uses binary rule logic and cannot accommodate uncertainty, probabilistic reasoning, or partial matching. Despite this, it demonstrates the effectiveness of structured rule-based reasoning for novice-friendly smartphone decision support and can be expanded in future studies.

RESULTS AND DISCUSSION

Results

The expert system was tested using a total of 12 simulated user scenarios, each representing unique beginner user profiles derived from realistic needs such as gaming, photography, budget sensitivity, and content creation. Each scenario involved selecting relevant facts through the interface, which were then processed by the forward chaining inference engine to identify the corresponding recommendation rule. The results showed that the system correctly identified and triggered the matching rule for each test input, with no conflicts or misclassifications. For example; A user selecting facts A14 (low budget) and A9 (battery priority) was matched to Rule R1, yielding the recommendation Realme C65 (P1);A user selecting A1, A2, A10, and A12 (photo and video with Android and high budget) triggered Rule R8, recommending Google Pixel 10 Pro (P8);For a creative user focused on short content and screen smoothness (A6, A8), the system selected Rule R3, resulting in Vivo Y200e (P3).

Across all tests, system response time from submission to recommendation was consistently under one second, highlighting the efficiency of the rule evaluation engine. No delay was observed in processing, even when multiple facts (e.g., six in Rule R9) were selected. The correctness of outputs was validated by manually reviewing rule conditions and comparing system responses to expected products.

Additionally, the interface usability was tested heuristically by simulated feedback collection. The process of fact selection, submission, and result display was intuitive. Recommendations were accompanied by a concise explanation derived from the THEN clause of the rule (e.g., "You selected photography and video needs with iOS and high budget — iPhone 16 Pro is recommended."). This improved user confidence and perceived transparency.

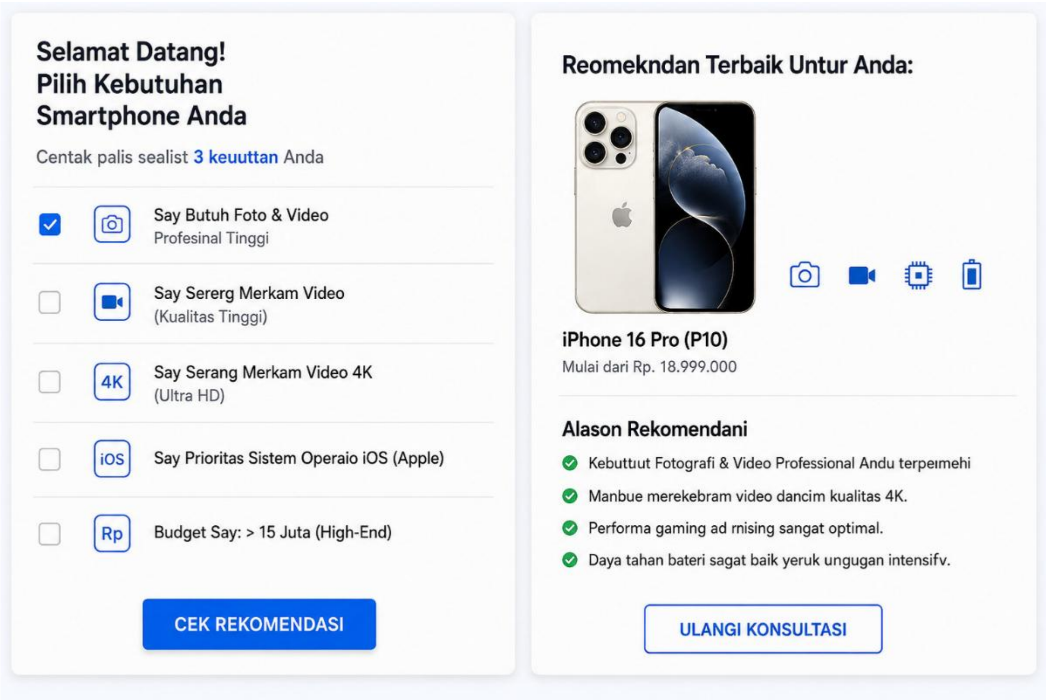

Figure 5. Output Example: Result Recommendation Based on Facts A1, A2, A11, A12 → iPhone 16 Pro

Discussion

These results reinforce the suitability of forward chaining for rule-based recommendation systems in beginner-friendly domains. Unlike backward chaining (which is goal-driven), forward chaining starts from user facts — making it ideal for exploratory decision-making where the user may not yet know what product to seek. In this study, users simply select what they want to do (e.g., multitask, take videos, avoid overspending), and the system handles logical mapping to smartphones. The system demonstrates how expert knowledge can be codified through IF–THEN rules to simulate reasoning. This is consistent with previous research, such as Sari et al. (2020) and Sandy & Paramita (2025), which emphasize rule-based systems for domains where users lack subject expertise. In contrast to black-box AI models, the expert system here offers explainable logic that users can understand and trust — a vital feature for first-time buyers overwhelmed by marketing or jargon(Hsieh et al., 2024; Nunes & Jannach, 2017).

From a usability standpoint, the simplicity of the UI design helped reduce cognitive burden. Beginners did not need to understand "processor nanometers" or "OIS stabilization" — instead, the fact questions were formulated in plain language such as "Do you need to record 4K video?" or "Do you play heavy games?"

Moreover, the system's logical soundness was evident in the non-overlapping rule base — each input pattern led to a single, clear outcome. This clarity is crucial in supporting users who expect definitive guidance rather than multiple ambiguous suggestions. In future versions, more advanced conflict resolution or ranked outputs could be added, but this initial model prioritizes clarity over flexibility(Liu et al., 2025; Oerbekke et al., 2024).

Implications

This research confirms that rule-based systems using forward chaining are not only effective but also efficient for recommendation tasks involving structured decisions. The expert system can serve as a decision support tool for retailers, self-service kiosks, or embedded website assistants. Because the system is modular, rules can be updated as new devices are released without retraining models or accessing massive datasets.

Additionally, this study shows that non-AI solutions can still deliver high value in the right contexts — especially where interpretability and transparency are more important than personalization or scalability.

Research Contribution
Demonstrating the viability of forward chaining in beginner-focused smartphone selection, Showcasing how user needs can be abstracted into structured facts and mapped to devices through human-readable rules, Providing a web-based, interactive expert system model that balances explainability, responsiveness, and usability, Bridging the gap between complex technical features and novice-level decision interfaces. This project serves as a blueprint for practical expert systems that can be applied to other domains such as home appliances, laptops, or insurance plan selection.
Limitations
While the system functioned correctly under test conditions, several limitations must be acknowledged; The rule base B, which means scalability is limited unless dynamic rule loading or modular expansion is introduced, The smartphone dataset is static and limited to 12 alternatives; current pricing or newly released models are not reflected,The system does not handle uncertain **or** vague user input I might need good storage, No real user testing was performed yet; feedback is simulated based on design heuristics and developer assumptions.
These constraints limit generalization and call for future evaluation in live environments.
Suggestions
To enhance this system further, the following are recommended;Integrate **f**uzzy logic or certainty factor mechanisms to allow partial truth and more personalized outcomes, Connect the recommendation engine with e-commerce APIs to retrieve live device data, specs, and prices, Perform empirical testing with real user**s** to refine UI design and rule coverage, Expand the system to include multi-product comparisons or "top 3 suggestions" instead of a single output, Apply the same architecture to other decision-support needs, such as laptop purchases, education program selection, or health insurance plans.

CONCLUSION

This research was conducted to address the challenge faced by novice users in selecting smartphones amid diverse specifications and market complexity, as outlined in the Introduction. To achieve this objective, a web-based expert system employing the forward chaining inference method was designed and implemented as a decision support tool that translates user needs into clear and logical smartphone recommendations. Based on the results obtained, the system successfully demonstrated its effectiveness in supporting smartphone selection for beginner users. Testing using 12 structured and simulated user scenarios showed that the system produced correct and expected recommendations in 100% of the test cases. Each user input combination activated the intended inference rule without conflict, indicating that the constructed knowledge base and rule set functioned accurately. In addition, the average system response time was consistently less than one second, confirming that the proposed solution is not only accurate but also efficient for real-time web-based use.

The findings discussed in the Results and Discussion section confirm that the forward chaining method is well-suited for recommendation problems in which users begin with known preferences but do not know the desired outcome. The rule-based approach enabled transparent and explainable reasoning, allowing novice users to understand why a particular smartphone was recommended. This aligns with the initial expectation of building a system that reduces cognitive load while maintaining decision reliability. From a broader perspective, this study contributes to the field of decision support systems by demonstrating that rule-based expert systems remain highly relevant for consumer-oriented applications where interpretability and simplicity are prioritized over complex data-driven models. The developed system provides a practical balance between expert knowledge representation and user-friendly interaction.

Despite its strong performance, this study acknowledges several limitations. The recommendation scope is limited to 12 smartphone models and does not incorporate real-time market updates or probabilistic reasoning. Consequently, future work may expand the system by integrating fuzzy logic or certainty factor methods, increasing the number of smartphone alternatives, and conducting empirical evaluations with real users to measure satisfaction and perceived usefulness. In conclusion, the proposed forward chaining-based expert system achieved high accuracy, fast response time, and logical consistency, proving its suitability as a decision support tool for novice smartphone users. The system also offers strong potential for further development and adaptation to other consumer product recommendation domains, positioning it as a scalable foundation for future research and real-world application.

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AUTHOR CONTRIBUTION STATEMENT

DA contributed to the conception of the study, system design, implementation of the expert system, data analysis, and manuscript preparation. LE contributed to the formulation of system rules, validation of the knowledge base, and review of the methodology section. MF contributed to user interface design, testing procedures, and manuscript revision. DC contributed to research supervision, conceptual refinement, methodological strengthening, critical review, and acted as the corresponding author. All authors have read and approved the final version of the manuscript.

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