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User Perceptions of a Home Automation System: A TAM-Based Evaluation

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***Abstract* – The study explores user perceptions of a newly developed home automation system, using the Technology Acceptance Model (TAM) as a theoretical framework to guide the evaluation. The system includes advanced features for security, energy efficiency, and user convenience. It was tested in three different residential environments to evaluate its adaptability. Participants interacted with the system in a controlled laboratory setting and completed a structured survey. The study examines core TAM constructs – perceived ease of use, perceived usefulness, and behavioural intention – alongside additional factors such as trust and privacy concerns. The results highlight strong user satisfaction and intention to adopt the system, while also identifying areas for improvement, particularly in privacy assurance and device control. The findings offer practical recommendations for developers to enhance usability, transparency, and user trust. The research contributes to the smart home literature by demonstrating TAM's applicability to real-world systems and by providing insights into the practical and user-centred factors that influence technology acceptance.**

***Keywords* – Energy efficiency, home automation, home security, IoT, remote monitoring, smart home, TAM.**

I. Introduction

The rapid advancement of smart technologies has transformed the landscape of home automation, offering users unprecedented control over various aspects of their living environments, such as lighting, security, heating, and entertainment systems. These innovations have not only increased convenience but also promised energy efficiency and enhanced security. Despite the potential benefits, the adoption of home automation systems remains inconsistent, with varying levels of acceptance among users. Understanding the factors that influence this acceptance is critical for the continued development and successful deployment of such technologies [1], [2].

The Technology Acceptance Model (TAM), developed by Davis in 1989, has been widely employed to examine user acceptance of new technologies. The model identifies two primary factors – perceived usefulness and perceived ease of use – that influence users' decisions to adopt technology. TAM has proven effective across various technological domains, from information systems to mobile applications, making it a suitable framework for evaluating home automation systems [3], [4].

This paper examines the application of the Technology Acceptance Model (TAM) in the context of a newly developed home automation system. The system, designed with features such as energy management, enhanced security, and user-centric automation, evolved through multiple iterations based on thorough research, which involved gathering requirements and conducting an international survey to identify the key preferences of modern smart home users. The system was tested in three distinct environments: one apartment, one studio, and one detached house. These varied test environments provided critical insights into its flexibility and functionality, demonstrating the system's adaptability across different living situations [5]–[7].

The home automation system offers a comprehensive set of features designed to enhance convenience, security, and energy efficiency. A leaderboard gamifies energy consumption, encouraging users to adopt more sustainable habits. The system supports time- and temperature-based scheduling for precise control of devices, ensuring comfort and energy savings. Security is a priority, with encrypted private and public key login to protect user data, and mechanisms to monitor and block suspicious login attempts, preventing unauthorized access. Users can control the system remotely through multiple methods, ensuring flexibility and reliability. Alerts are seamlessly delivered to users, even in offline scenarios, enhancing safety and awareness. The user-friendly interface simplifies navigation, making advanced features accessible to everyone. Additionally, the system enables energy consumption monitoring and supports integration with various brands and technologies, including Tuya, Orvibo, TP-Link, Sonoff, VStarcam, Blink, and multiple radio frequency sensors, ensuring compatibility with a wide range of devices [5]. For a detailed demonstration of the system's features and functionality, please refer to the footnote link[2].

By applying TAM in this context, the research aims to contribute to the growing body of literature on smart home technology adoption, offering insights into the psychological

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and practical factors that drive user acceptance. These findings are particularly relevant for developers, designers, and stakeholders in the smart home industry who seek to create more user-friendly, widely adopted systems. The remainder of this paper is structured as follows: Section 2 reviews the literature on the Technology Acceptance Model and its applications in home automation. Section 3 outlines the research methodology. Section 4 presents the results and analysis. Section 5 provides a critical discussion of the findings and their implications, along with recommendations for future work. Section 6 concludes the paper.

This study contributes to the field by applying TAM to a fully developed home automation system, evaluated across three distinct residential environments. Although user interaction has been conducted in a controlled laboratory setting, the system's real-world deployment provides a strong foundation for assessing user perceptions. While much of the existing research has focused on conceptual models or survey-based evaluations, this study offers empirical insights through direct user engagement with a functioning system. It also extends TAM by incorporating trust and privacy concerns, and by examining underexplored features such as energy consumption gamification. These contributions provide practical guidance for developers and researchers aiming to bridge the gap between theoretical frameworks and real-world smart home adoption.

II. Literature Review

The Technology Acceptance Model (TAM) has been a fundamental framework for understanding the factors that drive technology adoption since Davis introduced it in 1989. Grounded in theories of reasoned action and planned behaviour, TAM simplifies the evaluation of user acceptance by focusing on two primary constructs: perceived usefulness (PU) and perceived ease of use (PEOU). Over time, TAM has been adapted and expanded across various technological domains, offering valuable insights into how users interact with different systems [3].

As home automation technologies have advanced, TAM has become increasingly relevant. Smart devices and the Internet of Things (IoT) now allow for the automation of household tasks, including lighting, security, and climate control. These technologies, while innovative, require broad user acceptance to fully integrate into everyday life. However, adoption rates have varied, depending on users' perceptions of the technology [8].

Many studies have investigated the factors influencing the adoption of home automation systems, with TAM frequently serving as a foundational framework. While perceived usefulness and perceived ease of use remain central, additional factors, such as trust in the system, privacy concerns, and the simplicity of use, have emerged as critical in determining user acceptance in home environments. This literature review consolidates existing research on TAM and its application to home automation, highlighting the primary factors that impact user decision-making [9], [10].

In the sections that follow, the core elements of TAM are discussed, along with key extensions and their relevance to home automation. This review also explores additional influences, such as privacy concerns and the perceived security of these systems, which play an increasingly important role in the context of smart home technology adoption.

In their paper, Yonghee Kim et al. integrate the Technology Acceptance Model with the Value-based Adoption Model (VAM) to explore the adoption of IoT-based smart home services. The study highlights that perceived value, influenced by perceived benefits and sacrifices, plays a crucial role in adoption decisions. TAM's core constructs, such as perceived usefulness and ease of use, are extended by incorporating factors like privacy risk and innovation resistance. This comprehensive approach provides a nuanced understanding of how users evaluate and decide to adopt smart home technologies, emphasizing the importance of balancing benefits with potential risks and sacrifices [10].

The paper written by Ahmed Shuhaiber and Ibrahim Mashal investigates the factors influencing the acceptance and usage of smart homes. By extending TAM to include trust, awareness, enjoyment, and perceived risks, the study provides a comprehensive analysis using the Structural Equation Modelling based on the Partial Least Squares approach. The findings reveal that trust, awareness, and enjoyment significantly impact users' attitudes towards smart homes, affecting their intention to use them. Additionally, perceived risks negatively influence trust. The study highlights the importance of educating users and ensuring the trustworthiness of smart home technologies to enhance adoption rates. This research offers valuable insights for smart home providers aiming to increase user acceptance and improve marketing strategies [8].

Alejandro Valencia-Arias et al. provide a comprehensive analysis of the factors influencing the adoption of smart home technologies. The authors systematically review existing literature to identify key theories, variables, and research trends. They emphasize the importance of perceived reliability, usefulness, and ease of use [2].

In their paper, Schuster and Habibipour [11] examine how privacy and security issues influence the adoption of IoT devices in smart homes. The study reveals that these concerns significantly affect two key constructs of TAM – Perceived Usefulness (PU) and Perceived Ease of Use (PEOU). The authors find that a lack of trust in the security measures of IoT devices negatively impacts users' perceptions of usefulness, as users may believe the risks outweigh the benefits of convenience. Similarly, concerns over data breaches and unauthorized access reduce the ease with which users feel they can safely operate these devices, negatively affecting their perception of ease of use. The study underscores the need for enhanced security protocols and better communication about privacy features to alleviate these concerns and improve both PU and PEOU, thus fostering greater IoT adoption in smart homes [11].

This aligns with the findings of Magara and Zhou, who also highlight the critical role privacy and security concerns play in

shaping users' attitudes toward smart home technologies. Their research, based on a quantitative survey, reveals that security concerns are a major barrier to adoption, with around 76.2 % of the variance in adoption behaviour explained by these concerns. The paper concludes that perceived privacy risks and security vulnerabilities significantly reduce users' perceived ease of use and usefulness of IoT systems, emphasizing the need for secure design practices and privacy-by-design principles in smart home technologies [9].

In the paper "A Comprehensive Acceptance Model for Smart Home Services", the authors propose an integrated model that combines the Technology Acceptance Model with the Innovation Diffusion Theory (IDT) and the Theory of Planned Behaviour (TPB) to better understand user acceptance of smart home services (SHS). The study introduces several factors influencing the adoption of SHS, including perceived convenience, perceived connectedness, perceived cost, and perceived privacy risk. By conducting a survey of 750 participants and using structural equation modelling, the authors found that perceived ease of use and perceived usefulness, alongside these additional factors, significantly impact users' behavioural intentions to adopt SHS. The research highlights the importance of designing systems that not only focus on user convenience and cost-efficiency but also address privacy concerns and system integration. This comprehensive approach provides valuable insights into how users evaluate smart home technologies, emphasizing the critical role of perceived benefits and risks in shaping adoption decisions [12].

In the paper written by Yan Zhang, the author explores the influence of perceived privacy and security on users' behavioural intentions, particularly in the context of face recognition technology, through the lens of TAM. The study introduces trust as a mediating factor between perceived privacy, security, and the core TAM constructs – perceived ease of use (PEOU) and perceived usefulness (PU). The results highlight that while perceived security significantly enhances user trust and positively influences PU and PEOU, perceived privacy does not have a direct impact on trust. This suggests that users are more concerned with security guarantees than privacy, as long as they perceive the technology as secure. The study concludes that building trust through robust security features is essential for driving the adoption of face recognition technologies, and similar considerations may apply to other smart technologies, including IoT-based systems like smart homes [13].

Despite the extensive application of TAM in smart home research, most studies rely on hypothetical scenarios or conceptual models. Few have examined user perceptions of a fully operational system through hands-on interaction. This study fills that gap by providing empirical evidence from a lab-based evaluation of a complete home automation solution, incorporating underexplored features such as gamified energy management.

III. Research Methodology

This study adopts a mixed methods approach to evaluate user acceptance of the newly developed home automation system, using TAM as the guiding framework. The methodology consists of three key components: participant selection, data collection, and data analysis. These elements are designed to measure key factors such as perceived usefulness, perceived ease of use, trust, and privacy concerns, all of which contribute to the users' behavioural intentions toward adopting the system.

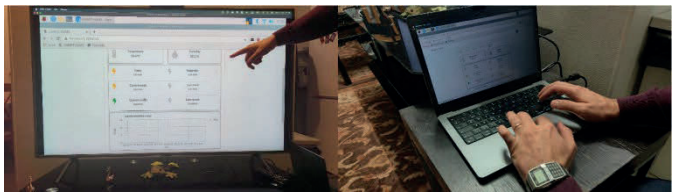

Fig. 1. System demonstration.

A. Participant Selection

A total of 20 participants were selected for the study, all of whom were familiar with smart home technologies and actively used some form of home automation or security system in their residences. This ensured that participants had prior experience with similar technologies, providing a knowledgeable perspective when engaging with and evaluating the home automation system during the study. Although the system was tested in real residential environments, participants interacted with it in a controlled lab setting, where its features and capabilities, such as energy management, security, and automated control of household tasks, were demonstrated to them. Following the demonstration, users were allowed to ask questions, fostering detailed discussions on the system's functionalities. This controlled setting ensured consistency in how participants were introduced to the system and enabled them to engage with it in a manner that facilitated meaningful feedback and insights.

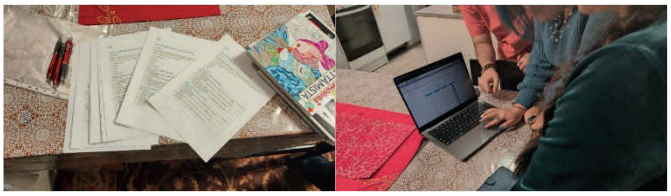

Fig 2. Q&A and survey completion process.

B. Data Collection

Data were collected using both quantitative and qualitative methods. A structured survey was employed to measure the core TAM constructs, including PU, PEOU, Behavioural Intention (BI), and additional factors such as trust and privacy concerns. The survey used a 5-point Likert scale ranging from strongly disagree to strongly agree to capture participant responses after their interaction with the system in the lab. The survey was structured into different sections to target specific TAM constructs and other relevant factors:

- Perceived Usefulness
  - The demonstrated home automation system would help me complete tasks efficiently.
  - The demonstrated system provided a convenient way to manage home devices.
  - I found the system helpful for improving the control of household devices.
  - Using the demonstrated system would make household management more effective in real life.
- Perceived Ease of Use
  - The home automation system was straightforward to understand during the session.
  - I found it easy to perform tasks and navigate through the system features.
  - The instructions provided made it easy to understand the system's capabilities.
  - The system's interface and controls were intuitive.
- Behavioural Intention to Use
  - I intend to continue using the home automation system regularly.
  - I would recommend this system to others interested in home automation.
  - I will likely use the system as my primary means of controlling home automation.
- Trust
  - I trust that the home automation system is secure and reliable.
  - I believe the system will work consistently as intended.
  - I trust the system to maintain the privacy of my data.
  - The system's performance gave me confidence in its overall dependability.
- Privacy Concerns
  - I am not concerned about the privacy of my data when using the home automation system.
  - I trust that my personal information will not be misused by the system.
  - I am not worried about unauthorized access to my home automation data.
  - I feel confident providing personal information to the system without concern for privacy risks.

IV. Results

The study evaluated user perceptions and acceptance of a home automation system, focusing on five key dimensions: user satisfaction, usability, reliability, security, and intention to use. Data were collected from a total of 20 participants through a structured survey. The survey responses were initially recorded on paper and later digitized to facilitate more efficient analysis.

Quantitative responses were analysed using frequency and percentage distributions to identify trends and patterns in user perceptions. Qualitative responses were carefully reviewed, categorised, and summarised to provide a richer understanding of participant feedback. This combination of quantitative and qualitative insights offers a comprehensive perspective on the strengths of the system and areas requiring improvement.

A. User Satisfaction and Usability

Most participants expressed high satisfaction with the system's ability to complete tasks efficiently and improve control over household devices. Statements such as *"The demonstrated home automation system would help me complete tasks efficiently"* and *"The demonstrated system provided a convenient way to manage home devices"* were overwhelmingly rated as "**Strongly Agree**" or "**Agree**" by the majority. For example, 16 out of 20 participants strongly agreed that the system made household management more effective, while others were neutral in their responses.

The system's usability was positively reviewed, with most participants finding it straightforward to understand and navigate. Key statements such as *"The home automation system was straightforward to understand during the session"* and *"The instructions provided made it easy to understand the system capabilities"* received **Strongly Agree** or **Agree** ratings from most respondents. However, some participants highlighted areas for improvement, such as incorporating a more colourful user interface and adding search functionality for enhanced usability.

TABLE I
Perceived Usefulness

Question	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
The demonstrated home automation system would help me complete tasks efficiently.	70 %	10 %	15 %	5 %	0 %
The demonstrated system provided a convenient way to manage home devices.	70 %	25 %	5 %	0 %	0 %
I found the system helpful for improving the control of household devices.	70 %	25 %	5 %	0 %	0 %
Using the demonstrated system would make household management more effective in real life.	45 %	35 %	20 %	0 %	0 %

TABLE II
PERCEIVED EASE OF USE

Question	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
The home automation system was straightforward to understand during the session.	65 %	30 %	5 %	0 %	0 %
I found it easy to perform tasks and navigate through the system features.	40 %	50 %	10 %	0 %	0 %
The instructions provided made it easy to understand the system's capabilities.	50 %	35 %	15 %	0 %	0 %
The system's interface and controls were intuitive.	55 %	35 %	10 %	0 %	0 %

B. Reliability and Security

Trust in the system's reliability and security was mixed. While many participants believed the system would work consistently as intended, concerns regarding privacy and unauthorized access were raised. A notable number of participants expressed neutral or negative opinions on statements such as *"I trust the system to maintain the privacy of my data" and "I feel confident providing personal information to the system without concern for privacy risks"*. Feedback comments emphasised the need for features like two-factor authentication, real-time hacking attempt notifications, and more transparent explanations of security mechanisms.

TABLE III
TRUST

Question	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
I trust that the home automation system is secure and reliable.	20 %	40 %	30 %	10 %	0 %
I believe the system will work consistently as intended.	20 %	45 %	30 %	5 %	0 %
I trust the system to maintain the privacy of my data.	40 %	30 %	30 %	0 %	0 %
The system's performance gave me confidence in its overall dependability.	10 %	65 %	10 %	15 %	0 %

TABLE IV
PRIVACY CONCERNS

Question	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
I am not concerned about the privacy of my data when using the home automation system.	10 %	20 %	40 %	25 %	5 %
I trust that my personal information will not be misused by the system.	35 %	20 %	35 %	5 %	5 %
I am not worried about unauthorized access to my home automation data.	10 %	35 %	25 %	25 %	5 %
I feel confident providing personal information to the system without concern for privacy risks.	10 %	35 %	25 %	30 %	0 %

C. Intention to Use

Participants indicated a strong intention to adopt the system for regular use. Statements such as *"I intend to continue using the home automation system regularly"* and *"I would recommend this system to others interested in home automation"* received mostly **Strongly Agree** or **Agree** responses. Despite the enthusiasm, several participants expressed concerns about the system's dependency on electricity and the lack of advanced features for controlling specific devices, such as washing machines and dishwashers.

TABLE V
BEHAVIOURAL INTENTION TO USE

Question	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
I intend to continue using the home automation system regularly.	45 %	25 %	25 %	5 %	0 %
I would recommend this system to others interested in home automation.	70 %	20 %	5 %	0 %	5 %
I will likely use the system as my primary means of controlling home automation.	35 %	40 %	20 %	5 %	0 %

D. Qualitative Feedback

Open-ended responses revealed several recurring themes. Participants appreciated the system's ease of use, intuitive design, and engaging features such as the gamified leaderboard, describing it as a valuable addition to their home setup. However, they also provided constructive feedback on areas like user interface design, security enhancements, and accessibility features. For instance, one participant suggested integrating services tailored for individuals with disabilities, while another highlighted the importance of robust security measures to mitigate hacking risks.

During open discussions, participants expressed broader privacy concerns, noting that such apprehensions were not limited to the home automation system in question. Comments like *"every computerized system is hackable"* and *"even big corporations aren't immune to hacking attempts"* reflected general scepticism about the security of technology rather than specific criticisms of the demonstrated system.

V. Critical discussion

The findings from this study provide valuable insights into the user acceptance and perceptions of a newly developed home automation system. While the results indicate high levels of satisfaction, usability, and intention to use, the feedback also highlights important areas for improvement, particularly regarding system security, privacy, and advanced features.

A. User Satisfaction and Usability

The system's ease of use and intuitive design were universally appreciated by participants, with 80 % agreeing that it simplified household management and improved control over devices. Additionally, 95 % of participants stated that the system enhanced their control over household devices. These findings align with the established user-centric design principles, which prioritize simplicity and intuitiveness as critical factors for technology adoption. However, the study also uncovered a demand for a more visually appealing user interface and added functionalities such as search features to further enhance usability. These suggestions underscore the importance of iterative design processes that incorporate user feedback to refine system interfaces and maintain engagement.

B. Reliability and Security

The mixed responses to reliability and security questions reflect a critical area of concern for users. While most participants trusted the system's reliability, 30 % remained neutral about its ability to maintain privacy. Qualitative feedback revealed specific desires for two-factor authentication, hacking attempt notifications, and greater transparency regarding security measures. These concerns are consistent with broader industry trends, where user confidence in IoT systems often hinges on the robustness of their security features. Addressing these concerns is crucial to building trust and ensuring the system's long-term adoption.

C. Privacy Concerns

The study also highlighted privacy concerns, with only 55 % of participants indicating confidence that their personal information would not be misused. Interestingly, open-ended feedback suggested that these concerns were not unique to the home automation system but reflected broader apprehensions about technology in general. Comments like "every computerized system is hackable" and "even big corporations aren't immune to hacking attempts" indicate a pervasive scepticism about the security of digital systems. These insights suggest that while the system's privacy features need to be robust, clear communication about these features and their effectiveness is equally important to reassure users.

D. Intention to Use

Despite security and privacy concerns, the system demonstrated strong adoption potential, with 70 % of participants indicating they would recommend it to others and the same percentage expressing a willingness to use it regularly. This suggests that the perceived benefits of the system, such as ease of use and energy management features, outweigh user apprehensions for most participants. However, feedback about the system's dependency on electricity and the lack of advanced device control features (e.g., for washing machines and dishwashers) highlights areas where enhancements could further improve adoption rates.

The system included energy management features, such as a gamified leaderboard, and received positive feedback from participants, who indicated a willingness to use and recommend it. This shows that incorporating motivational design elements into smart home technologies can promote sustainable behaviour, a topic still underexplored in previous TAM-based evaluations.

E. Critical Reflection

This study highlights the strengths of the home automation system, particularly its usability and potential for widespread adoption. At the same time, it underscores the importance of addressing user concerns around security, privacy, and functionality. By leveraging user feedback and adopting an iterative design approach, the system can continue to evolve and meet the needs of a broader user base, solidifying its position as a reliable and user-friendly solution for smart home automation.

VI. Conclusion

This study provides valuable insights into user acceptance of home automation technology through the lens of TAM. The research, conducted with 20 participants in a controlled laboratory environment, revealed several key findings that contribute to our understanding of smart home adoption factors.

The results demonstrate strong support for the core TAM constructs, with perceived usefulness and perceived ease of use showing significant positive influence on users' behavioural intentions to adopt the system. Notably, 80 % of participants found the system effective for household management, and 95 % agreed it enhanced their control over household devices. These findings validate the system's fundamental design

principles while highlighting the importance of user-centric development in home automation technologies.

However, the study also revealed critical areas requiring attention, particularly regarding security and privacy concerns. While participants expressed high satisfaction with the system's usability and functionality, their trust in data privacy and security features was more reserved, with only 55 % expressing confidence in the system's ability to protect personal information. This highlights a crucial gap between technological capability and user trust that needs to be addressed in future developments.

The research has several important implications for practitioners and developers in the smart home industry. First, it emphasises the need to balance advanced functionality with an intuitive user interface design. Second, it highlights the critical importance of implementing and communicating robust security measures to address user privacy concerns. Third, it suggests that future developments should focus on expanding device compatibility and implementing fail-safe mechanisms to address concerns about system reliability.

In conclusion, while the evaluated home automation system demonstrates strong potential for widespread adoption, its long-term success will depend on how effectively future iterations address user concerns related to privacy, security, and advanced device functionality. This study contributes to the smart home literature by applying TAM to a fully developed system evaluated through direct user interaction in a controlled lab setting, bridging the gap between theoretical models and practical implementation. Furthermore, the inclusion of user feedback on usability, security, and innovative features, such as energy gamification, underscores the importance of user-centred design in driving adoption. These insights provide a valuable foundation for future development and research in the field of smart home technologies.

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