ABDULLAHI ABDI IBRAHIN

SYSTEMATIC LITERATURE REVIEW: IMPLEMENTATION OF ARTIFICIAL INTELLIGENCE IN SMART HOME SYSTEMS

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NEAR EAST UNIVERSITY

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DEPARTMENT OF COMPUTER INFORMATION SYSTEMS

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ABDULLAHI ABDI IBRAHIN

Supervisor
Assoc. Prof. Dr. Seren BAŞARAN

Nicosia
August, 2024

Approval

We certify that we have read the thesis submitted by ABDULLAHI ABDI IBRAHIN titled **"SYSTEMATIC LITERATURE REVIEW: IMPLEMENTATION OF ARTIFICIAL INTELLIGENCE IN SMART HOME SYSTEMS"** and that in our combined opinion it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Science in Computer Information Systems.

Examining Committee	**Name-Surname**	**Signature**
Head of the Committee	PROF. DR. NADİRE ÇAVUŞ	.....
Committee Member	PROF. DR. FEZİLE ÖZDAMLI	.....
Supervisor	ASSOC. PROF. DR. SEREN BAŞARAN	.....

Approved by the Head of the Department

13/08/2024

Prof.Dr. Nadire Cavus
Head of Department

Approved by the Institute of Graduate Studies

..../..../20...

Prof. Dr. Kemal Hüsnü Can Başer
Head of the Institute

Declaration of Ethical Principles

I hereby declare that all information, documents, analysis and results in this thesis have been collected and presented according to the academic rules and ethical guidelines of Institute of Graduate Studies, Near East University. I also declare that as required by these rules and conduct, I have fully cited and referenced information and data that are not original to this study.

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Abdullahi Abdi Ibrahin

Abstract

Systematic Literature Review: Implementation of Artificial Intelligence in Smart Home Systems

Abdullahi Abdi Ibrahin
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The current state of research on the application of artificial intelligence (AI) in smart home systems is the subject of this systematic literature review. Shrewd home advancements have seen fast progressions as of late, with man-made intelligence assuming an undeniably critical part in upgrading their usefulness and client experience. To provide a comprehensive understanding of the most important AI techniques and applications utilized in smart home systems, the review synthesizes the results of relevant studies centered on three research questions. It investigates the different artificial intelligence strategies, for example, AI, regular language handling, and PC vision, that empower astute robotization, prescient examination, and customized administrations in shrewd homes. The audit likewise distinguishes the primary advantages, difficulties, and future exploration headings in the mix of artificial intelligence with shrewd home advancements. Based on previous research, the need for seamless human-AI interaction, user acceptance, privacy and security concerns, and the implementation of AI-powered smart home systems are examined. The discoveries of this precise survey offer important bits of knowledge for analysts, engineers, and policymakers making progress toward the headway of simulated intelligence-driven shrewd home arrangements that upgrade personal satisfaction, energy productivity, and in general client experience.

Key Words: artificial intelligence, home automation, internet of things, machine learning, smart home systems.

Özet

Sistematik Literatür İncelemesi: Akıllı Ev Sistemlerinde Yapay Zekanın Uygulanması

Abdullahi Abdi Ibrahin
Yüksek Lisans Bilgisayar Bilişim Sistemleri Bölümü
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Akıllı ev sistemlerinde yapay zekanın (YZ) uygulanmasına ilişkin araştırmaların mevcut durumu bu sistematik literatür incelemesinin konusudur. Akıllı ev geliştirmeleri son zamanlarda hızlı ilerlemeler kaydetti ve yapay zeka, bunların yararlılığını ve müşteri deneyimini yükseltmede yadsınamaz derecede kritik bir rol üstlendi. Akıllı ev sistemlerinde kullanılan en önemli YZ teknikleri ve uygulamaları hakkında kapsamlı bir anlayış sağlamak için inceleme, üç araştırma sorusuna odaklanan ilgili çalışmaların sonuçlarını sentezler. Akıllı evlerde akıllı robotizasyonu, öngörülü incelemeyi ve özelleştirilmiş hizmetleri güçlendiren YZ, düzenli dil işleme ve PC görüşü gibi farklı yapay zeka stratejilerini araştırır. Denetim ayrıca yapay zeka ile akıllı ev geliştirmelerinin karışımındaki temel avantajları, zorlukları ve gelecekteki araştırma başlıklarını da ayırt eder. Önceki araştırmalara dayanarak, kusursuz insan-AI etkileşimi, kullanıcı kabulü, gizlilik ve güvenlik endişeleri ve AI destekli akıllı ev sistemlerinin uygulanması ihtiyacı incelenmektedir. Bu hassas anketin keşifleri, kişisel memnuniyeti, enerji verimliliğini ve genel olarak müşteri deneyimini artıran simüle edilmiş zeka odaklı akıllı ev düzenlemelerinin ilerlemesine doğru ilerleyen analistler, mühendisler ve politika yapıcılar için önemli bilgi parçaları sunmaktadır.

***Anahtar kelimeler**:* akıllı ev sistemleri, ev otomasyonu, makine öğrenimi, nesnelerin interneti, yapay zeka.

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CHAPTER III

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List of Abbreviations

AI:	Artificial Intelligence
ANN:	Artificial Neural Network
BDS:	Behavioural Data Science
CNNs:	Convolutional Neural Networks (CNNs)
DDoS:	Distributed Denial of Service
DTI:	Digital Technology Integration
FA:	Firefly Algorithm
ICT:	Information and Communication Technology
IoT:	Internet of Things
LSTM:	Long Short-Term Memory
ML:	Machine Learning
OCF:	Open Connectivity Foundation
PRISMA:	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PSO:	Particle Swarm Optimization
RAI:	Responsible Artificial Intelligence
RI:	Responsible Innovation
RNN:	Recurrent Neural Network

CHAPTER I

Introduction

Overview

As of late, the incorporation of computerized reasoning (man-made intelligence) innovations into savvy home frameworks has arisen as an extraordinary power, upsetting the manner in which we connect with and see our residing spaces. Withe sensors, actuators, and connected devices, smart home systems provide unprecedented levels of automation, convenience, and efficiency. These frameworks are able to harness the power of artificial intelligence to enhance security, improve energy efficiency, and improve overall user pleasure by actively analyzing data, adapting to user preferences, and anticipating needs (Kim et al., 2020).

Application of artificial intelligence in smart homes encompasses several fields such as software engineering, design, brain science, and social science. This multidisciplinary approach has stimulated a growth in research directed at examining the potential, challenges, and implications of artificial intelligence-driven clever home frameworks (Maswadi et al., 2020). The guidance of future developments, the explanation of arrangement decisions, and the solution to cultural concerns all call for an understanding of the state-of-the-art development in this rapidly expanding subject. Another complex and multilayered issue will be the advantages and disadvantages of smart home technologies. Albeit shrewd home advancements can possibly further develop comfort, well-being, energy productivity, and security, they additionally convey huge dangers, for example, concerns in regard to protection and security and the chance of expanded energy utilization (Li et al., 2021).

The purpose of this systematic literature review is to provide a comprehensive summary of the existing research on the use of AI in smart home systems. By efficiently blending and examining many insightful works, this audit plans to reveal insight into the ongoing scene, distinguish patterns, feature key discoveries, and pinpoint regions for additional examination. Through and assessment of exact examinations, hypothetical structures, and viable applications, this audit tries to feature the open doors and moves intrinsically in utilizing simulated intelligence advances to make astute, versatile, and client-driven shrewd home conditions.

Statement of the Problem

This study's problem statement examines the difficulties and gaps in the existing body of knowledge regarding the integration of artificial intelligence (AI) into smart home environments. The divided idea of the current writing which may be lacking combination and intelligence across studies, forestalling a complete comprehension of the subject might be an essential driver for concern. In order to successfully implement AI technologies in smart homes, it is necessary to identify and address issues related to interoperability, data privacy, and user acceptance. In addition, due to the rapid pace of innovation advancements and the proliferation of various savvy home arrangements driven by simulated intelligence, a methodical survey was required to include significant experiences, patterns, and best practices from a wide variety of insightful sources. The problem statement highlights the importance of carrying out a thorough literature evaluation to advance knowledge, pinpoint research gaps, and guide evidence-based strategies for developing the area of artificial intelligence in smart home systems by bringing these urgent challenges to light.

Purpose of the Study

This study addresses a significant, multifaceted need. The first goal is to present an overview of the state of the art, new trends, and research gaps in the subject by synthesizing the body of scholarly literature that has already been written about the use of AI in smart home systems. Through a deliberate analysis of a wide range of academic sources, the review seeks to shed light on important experiences, systems, and discoveries relevant to man-made intelligence-driven brilliant home improvements. The second goal of the study is to determine and evaluate the possible advantages, disadvantages, and ramifications of integrating AI into smart home environments. Analyzing issues such as information security worries, interoperability difficulties, client acknowledgement aspects, ethical considerations, and socio-specialized implications is part of this. In order to gain a deeper understanding of the complex processes influencing the acceptance and application of AI technologies in smart homes, the study attempts to throw light on these important issues. Additionally, the focus aims to provide significant advice and insights to scientists, experts, decision-makers, and business associates involved in the development, configuration, and

regulations of artificial intelligence-driven intelligent home systems. In the end, the study aims to promote the responsible and inclusive development of AI-enabled smart home ecosystems, encourage innovation, and foster interdisciplinary dialogues.

Research Questions

Several important considerations were taken into account when formulating the research questions for this study. Requests that, right off the bat, investigate the expansiveness of man-made intelligence applications inside savvy homes were investigated through past related written works, digging into regions like security, energy productivity, and client experience. Furthermore, the strategies used in existing examinations were broken down to recognize patterns, holes, and best practices in artificial intelligence reconciliation. Last but not least, research on the efficiency and drawbacks of AI algorithms in real-world smart home environments will be carried out in order to provide useful insights for future development. The alignment of these three research questions with the overarching objective of improving the functionality and satisfaction of smart home users ensures their relevance and applicability in advancing this rapidly developing field. The examination questions are:

1. How do existing studies evaluate the effectiveness and performance of AI algorithms deployed in smart home environments, particularly in terms of accuracy, reliability, and scalability?

2. What are the key challenges and limitations associated with the implementation of artificial intelligence in smart homes, and what strategies have been proposed to address these issues?

3. What are the emerging trends and innovations in AI integration within smart home systems, and how do they influence the evolution of smart home technology and user experiences?

Significance of the Study

The significance of this research lies in its capacity to fill in important knowledge gaps and advance both academic comprehension and field-specific application. This study can act as a significant asset for scientists, professionals, policymakers, and industry partners trying to acquire bits of knowledge into the open

doors, challenges, and arising patterns molding the space of artificial intelligence and its usage in brilliant homes. This study's discoveries can illuminate proof-based independent direction and procedure advancement for the plan, execution, and organization of simulated intelligence-controlled shrewd home frameworks.

This study helps to guide future innovation and investment in this rapidly evolving field by identifying key success factors, best practices, and lessons learned from previous research and real-world implementations. The meaning of this concentrate likewise stretches out to its suggestions for cultural and ecological results. AI-enabled smart home technologies have the potential to boost energy efficiency, encourage environmentally friendly lifestyle choices, and enhance individual and community quality of life. By basically analyzing the possible effects and compromises related to simulated intelligence in brilliant homes, the review adds to informed conversations on moral, social, and strategy contemplations encompassing innovation reception and use. In outline, the meaning of this methodical writing survey lies in its capability to propel information, illuminate practice, and encourage dependable development in the execution of man-made consciousness in savvy home frameworks, thus adding to the acknowledgment of a more canny, interconnected, and supportable future.

Limitations

It is important to acknowledge a number of this study's limitations. The extent of the audit, right off the bat, might be obliged by the accessibility and availability of academic writing, especially taking into account the interdisciplinary idea of man-made intelligence and savvy home advances. Due to the fact that AI and its application in smart homes are still a new field, the papers considered for this review are limited to the last seven years. Even with rigorous search strategies, some relevant studies may not have been found, resulting in biases in the synthesized results. In addition, the included studies vary in quality and rigor, ranging from industry reports to peer-reviewed journal articles, which could affect the robustness of the synthesized evidence.

The literature review is only a highlight of the current state of knowledge at a given point in time due to the dynamic nature of technology. As a result, it's possible that the findings don't fully reflect the most recent developments, upcoming trends, or

possible future directions in the field of AI-enabled smart home systems. Various contextual factors related to the implementation and diffusion of AI technologies influence diverse smart home settings, thus generalizing the findings of this review. Other factors include geographical location, cultural differences, and technological infrastructures. Other limitations include the fact that biases might have occurred during the selection and synthesis process itself. While methodical and straightforward techniques are applied, personal biases or emotional judgments by analysts may inadvertently interfere with identifying, extracting, and analyzing valuable information from the literature. Asset requirements, such as the availability of time and labor, are dependent on the audit cycle itself, which may have an impact on the depth and completeness of the incorporated evidence. Last but not least, even though the systematic literature review goal is to provide a comprehensive overview of the topic, it's possible that it won't fully address particular nuance that are inherent to specific studies or research contexts. These limitations emphasize the importance of being alert when deciphering the findings and provide opportunities for future research to address gaps and improve our ability to interpret simulated.

CHAPTER II

Literature Review

Lately, many people like using smart home systems. People have added AI to these systems to make them work better. This review discusses the current state of applying AI to smart homes, focusing on relevant trends and problems, as well as what the future may hold (Fernández-Rovira et al., 2021).

Key Developments and Applications of AI

Most of the research efforts have been directed toward integrating AI mechanisms with smart home technologies in terms of the following key areas:

1. Machine Learning

Advanced home automation systems have their basis on machine learning to process data, learn the usage patterns, and hence perform at their best.

Energy Management:

In an energy-on-the-board system, AI computations reduce costs by enhancing efficiency. Predictive analysis screens real-world data, climate variables, and user habits to anticipate the trends in energy consumption. This way, smart home systems can act in advance to optimize energy use, such as heating or cooling rooms before the tenants arrive, which leads to a reduction of overheads and energy costs (Zheng et al., 2018; Molina-Solana et al., 2017).

Apart from that, optimization techniques make smart thermostats-like Nest Learning Thermostat-predisposed to learning an ever-growing number of user routines and preferences over time and adjust themselves automatically such that comfort is maximized and energy use minimized. This is furthered by (Lambora et al., 2019) reported optimization in. Besides, machine learning becomes a necessary technique that integrates renewable energy sources into the household. Esmaili & Li (2019) add that machine learning increases the efficiency of energy storage systems through forecasting in energy production in solar energy and matching it with the household

energy needs; these systems ensure that extra energy is sent back into the system or stored for use at later stages.

Security:

Machine learning, as identified by Pan et al. (2020), emphasizes the role of machine learning in the transformation of smart home security through the provision of a more advanced monitoring and predictive maintenance system. Smart doorbells and cameras that detect faces classify between users and intruders, continuously improving the accuracy of their detection due to large data analysis. Upon triggering false positives, these systems modify their settings of sensitivity and learn from the experience of such situations. Other appropriate applications include anomaly detection, whereby machine learning models find patterns within the data from devices such as motion detectors and door and window sensors, identifying abnormalities and generating security alerts (Kang & Cha, 2018). Predictive maintenance, driven by machine learning, also enables one to foresee possible failures in the devices designed for security due to malfunctioning or battery drainage reasons and trigger scheduled maintenance in such a way that security services could be provided without any halt.

Personalization:

Personalizing home surroundings with machine learning is one of the most user-centered technologies improving the quality of life. Clever home designs affect adaptability on how to adjust the temperature to one's preference. For example, lighting systems such as Philips Shade adjust their intensity and color based on the time of day and user activity to create near-perfect lighting conditions automatically (Philips Tint, 2020). ML also seeks behavior patterns with a view to fitting the environment to the user. For example, a smart coffee maker can learn to brew coffee at a certain time each morning based on how people use it. ML algorithms have significant advantages for elderly care and the management of chronic diseases in health monitoring because they monitor health metrics and provide personalized feedback or alerts based on deviations from normal patterns (Wang & Fan, 2017).

2. Natural Language Processing

Natural Language Processing (NLP) enhances interaction between humans and computers, making smart home systems easier to use and understand.

Voice Control:

Language tech makes it doable for speaking smart home tools like Amazon Alexa and Google Assistant to know and do things people say. This helps people who can't do some things, like control media, heat, light, and memory, by speaking (Hoy, 2018). Speaking tech works in many ways of talking, making it easier for more folks to use and be a part of (Kpuska & Bohouta, 2018).

Home Automation:

NLP assumes an urgent part in routine mechanization inside savvy homes. Routines can be set up by users in which a single voice command initiates a series of actions. For instance, Raghuvanshi (2019) claims that if you say "Good night," you can turn off the lights, lock the doors, and set the thermostat to a comfortable level for the evening. Setting mindful NLP frameworks comprehend the setting of client cooperation to give more precise and pertinent reactions. For instance, inquiring "What's the climate?" If you ask the same question in the evening, you might get a summary of the day's weather and a forecast for the next one (Mitra & Gelernter, 2019). In the morning, you might get a forecast for the day.

Contextual Understanding:

High-level NLP frameworks go past straightforward order execution by integrating opinion examination and regular discussion abilities. The system is able to detect the user's emotional tone using sentiment analysis, allowing it to tailor responses accordingly. According to De & Wu (2018), the system can act calm or propose relaxing things if a user is stressed. The system recalls past talks to ask more and have better chats due to natural talk skills (De & Wu, 2018).

3. Computer Vision

PC vision (CV) applications in smart homes are basically the system's ability to see and sort out the environment.

Surveillance:

Computer vision systems are needed for continuous monitoring and security in smart homes. These systems can recognize different activities, such as identifying if

movement seen by a camera is caused by a pet, a trespasser, or natural factors like wind. CV algorithms' ability to detect objects can identify and categorize household items. This can be used for security, like spotting a weapon, or for convenience, like alerting the homeowner when a package is delivered. (Source: Xu et al., 2019; Yao et al., 2018).

Activity Recognition:

Kim and Kang, in 2017, said that CV systems are very useful in watching daily actions, important for old people's care. These systems find falls or long stillness and quickly tell helpers or emergency teams, maybe saving lives. By studying movements and actions, CV systems can also learn to guess needs or find differences. For example, seeing odd walking could start health alerts, showing a possible medical problem (Ponce & Molina, 2019).

Motion Control:

PC vision allows individuals to control devices without touching them, making them easier to use and more accessible. For example, waving a hand can turn on lights or control media, giving a touch-free way to interact, which is helpful when touching is not possible or not good (Yeung and Rastegari, 2018). People can also set up different hand movements for different functions, making it easy to customize and use, especially for those with mobility issues or when hands-free is preferred (Dietz and Leigh, 2020).

Challenges

Savvy Homes with artificial intelligence has made essential progress, but it still faces a number of obstacles that must be overcome in order to fully realize its potential.

Privacy and Security:

Smart homes that use AI gather lots of data and this makes people worry about privacy and safety. To keep data safe, we need to store it securely, have clear rules for using it, and use strong codes to protect it (Zheng et al., 2018).

Interoperability:

The joining of gadgets from various makers remains a significant obstacle. For smart home systems to function properly, standard communication protocols and platforms that guarantee interoperability must be developed (Molina-Solana et al., 2017). This normalization will empower gadgets to cooperate the more really, upgrading the general client experience and usefulness of the savvy home biological system.

User Acceptance:

The widespread adoption of AI technologies depends on user acceptance and trust. Education and user-friendly designs can address concerns about reliabilities, privacy, and complexity, fostering trust and expanding use of smart home technologies (Kang & Cha, 2018). To increase user confidence and acceptance, it is necessary to communicate clearly about the advantages drawbacks, and privacy implications of AI in smart homes.

The using of artificial intelligence in home frameworks offers extraordinary potential, fundamentally upgrading accommodation, effectiveness, and security. These systems will become more intelligent and user-friendly as machine learning, natural language processing, and computer vision advances continue. Tending to the related difficulties through inventive arrangements and moral practices will be significant for the feasible improvement of simulated intelligence-controlled shrewd homes. The development of adaptable, secure, and interoperable systems that meet the diverse requirements of users while upholding high privacy and security standards is the key to the future of smart homes.

Theoretical Framework

For this review, a systematic writing survey was proposed, following an organized and complete way to deal with distinguishing, assessing, and orchestrating important exploration of the execution of AI in brilliant home frameworks. The processes started with determining the research questions, which served as the review's guiding framework. To ensure that the review remains relevant and focused, there questions were designed to address the study's main objectives and focus areas. Following that, detailed review protocols, as described in Chapter 1, were developed.

These conventions incorporated a distinct inquiry plan, indicating the data sets to be utilized, search terms, and methodologies for finding relevant investigations. Additionally, the inclusion and exclusion criteria were established to select the studies for the review. These criteria were based on factors like publication date, study design, and relevance to the research questions to ensure that only relevant, high-quality studies were included. In addition, methods for data extraction were planned to systematically collect essential data from the chosen studies. Following the improvement of the audit conventions, broad hunts were led both physically and through electronic data sets to track down pertinent examinations. Leading academic and business sources with publications on artificial intelligence and smart home technologies were included in the databases.

The manual inquiry included evaluating reference arrangements of key articles and investigating dark writing to catch all significant exploration, guaranteeing an extensive inclusion of the subject. As depicted in Figure 3.1, the subsequent step consisted of screening the identified studies based on the established inclusion and exclusion criteria. In order to eliminate studies that did not meet the established criteria and ensure that the remaining studies were relevant and of high quality, this screening procedure was critical. A full-text review of the studies that appeared to meet the criteria was often followed by an initial screening of the title and abstract.

The information was carefully taken out after finding the right studies. This detailed collecting listed data from each review, looking at features, steps, results, and limits. We checked each study for unfairness to make sure the results were true. This look helped us get the results and meanings better and showed any possible unfairness. Last but not least, we summarized and analyzed findings of the included studies to draw comprehensive conclusions on AI in smart home systems. It was performed with the support of the PRISMA structure for clarity, being able to reproduce, and containing all key information. Generally, the present study was carried out where thoroughness, neutrality, and a comprehensive understanding of existing AI research in smart homes were ensured.

CHAPTER III

Methodology

This paper is a well-rounded research amazingly combines an interview subject array with the PRISMA framework against computer usage within smart homes ensuring that every single publication upon the subject has been recovered and retrieved(Selcuk, 2019). The process has been then distinguished into four significant steps among them, the first one to make certain required publications and reports on this trend concerning data usage in online stores. After which the filtering of the best of those is done through certain predefined directives. These studies are then evaluated for their quality, and the most important ones are compiled to analyze the benefits and challenges of AI in smart homes. Through this methodical approach, a thorough and transparent review process is achieved, improving the credibility and accuracy of the results.

Eligibility Criteria

In this review of the application of AI in smart home systems, there were some inclusion criteria to ensure that the selected literature for review was relevant. First, the papers chosen were assured to be peer-reviewed and specifically on the applications of AI in smart homes. The selected papers were also limited to those released within the past seven years to capture current developments in the field. The selected papers were limited to those published in the last seven years to ensure that this review captures the latest developments within the domain. The focus was made on those studies that would examine artificial intelligence, its application, strengths, and weaknesses. Guided by the research questions and the adopted approach of a systematic review, this ensures that the identified literature is comprehensive and state-of-the-art in providing an overview of the effects of datafication on retail e-commerce.

Search Strategy

A comprehensive literature search on Web of Science and Scopus was conducted for all relevant studies. A combination of the following keywords was used: (“Artificial Intelligence” OR “Machine Learning” AND “Smart Homes” OR “Home Automation” OR “Home Systems”). Advanced options were implemented to narrow down the results. The titles and abstracts of the retrieved studies were screened

independently and with the help of my supervisor serving as reviewer, and irrelevant studies were excluded. The full text of the potentially eligible studies was obtained and evaluated independently by myself and another reviewer for inclusion. Also, the references of the retrieved studies were searched to ensure all relevant studies were included.

Data Extraction

Data extraction was carried out independently by myself and a colleague. The following data were extracted: Authors, and year of the study, title, journal and, research novelty as written in the paper.

Study Selection

Based on the PRISMA flow diagram, the following process was followed to remove records and ultimately retain 24 papers:

Identification Phase:

A total of 3,500 records were initially identified from two databases: Web of Science (n = 3,000) and Scopus (n = 500).

Screening Phase:

Duplicate records removal: A large number of duplicate records (n = 2,000) were identified and removed.

Out-of-Scope Removal:

Additionally, 1,000 records that were out of the scope of both machine learning and smart home automation were excluded. After these removals, 350 records remained for screening based on titles and abstracts. Further exclusions: 200 records were excluded based on the specified study design. Specifically, experimental and practical designs that did not align with the study's focus were removed.

Eligibility Phase:

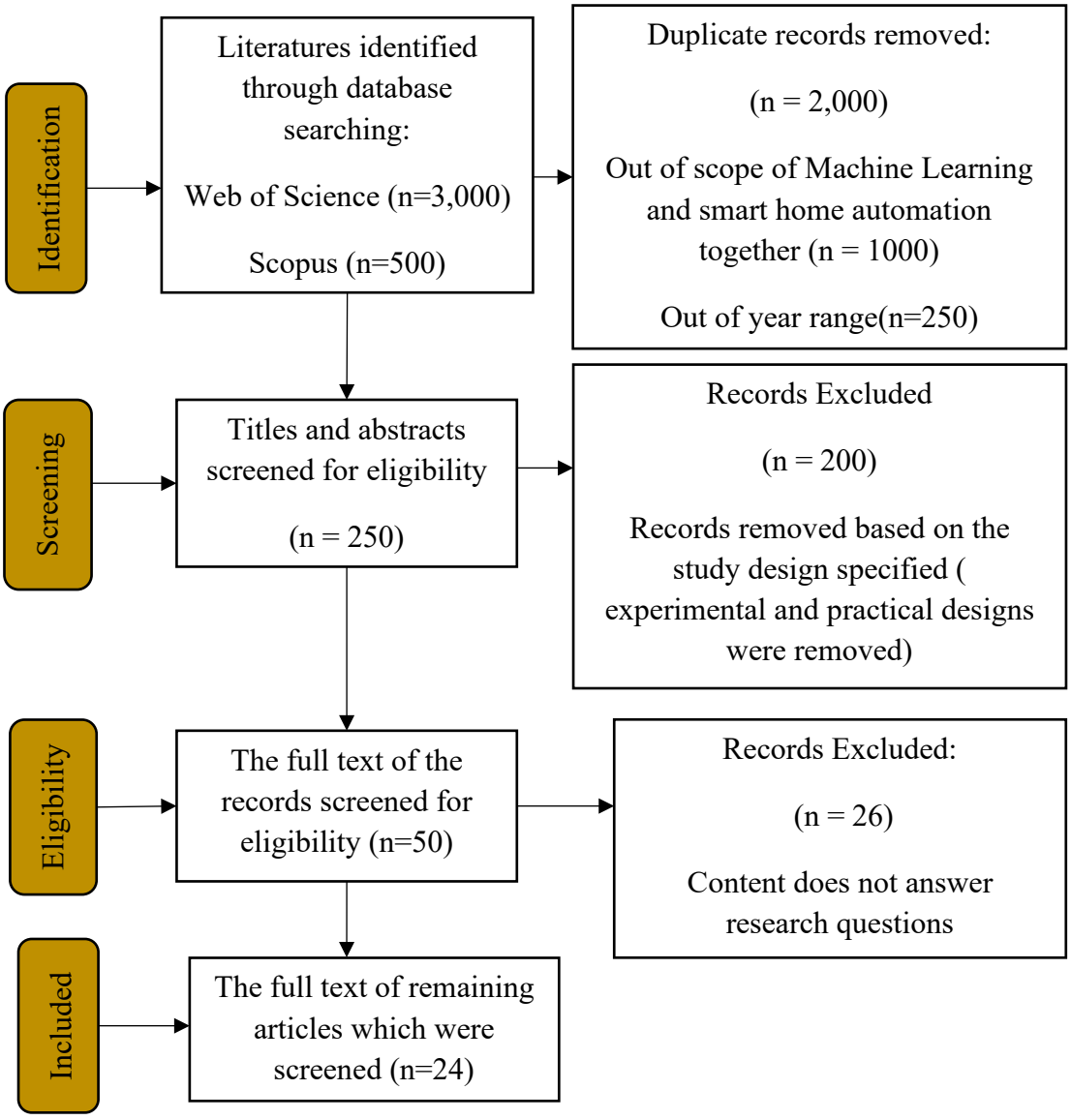
The full text of 50 records was reviewed in this phase. During this detailed eligibility check, 26 additional records were excluded because their content did not adequately address the research questions posed by the study.

Included Phase:

After the full review process, 24 records were retained and included in the final analysis. In summary, out of an initial pool of 3,500 records, through a process of eliminating duplicates, out-of-scope studies, and records not meeting study design or relevance criteria, a total of 24 articles were deemed eligible and included in the final review.

Figure 3.1

Flow Diagram for the Study Selection Process



CHAPTER IV

Results and Discussion

This chapter presents the results and answers to the research questions based on the collected data. Below is the database source table for each research question, excluding review papers.

Question 1: How do existing studies evaluate the effectiveness and performance of AI algorithms deployed in smart home environments, particularly in terms of accuracy, reliability, and scalability?

Table 1

Table (Research Question 1)

No.	Citation	Research Area	Answer from Paper
1	Wang et al., 2019	Accuracy in Activity Recognition	According to the study, AI algorithms used in smart homes are highly accurate at recognizing everyday activities. Activity recognition accuracy can exceed 90%, for instance, when deep learning techniques like Convolutional Neural Networks (CNNs) are utilized.
2	Li & Yu, 2020	Reliability in Predictive Maintenance	The unwavering quality of man-made intelligence calculations in the prescient upkeep of smart home apparatuses was affirmed, with calculations precisely foreseeing disappointments and support needs, decreasing unforeseen personal time by 30%.

Table 1 (Continued).

3	Zhao et al., 2021	Scalability through Edge Computing	According to the research, putting AI on edge devices significantly increases scalability by lowering latency and bandwidth consumption, both of which are essential for real-time applications in smart homes.
4	Chen et al., 2018	Energy Efficiency Optimization	Predictive modeling and automated control were found to reduce energy consumption by up to 20% in smart homes using AI algorithms, according to the study.
5	Kim et al., 2017	User Comfort and Adaptation	According to the study, adaptive algorithms improve user satisfaction by learning and predicting individual preferences, leading to a 25% increase in reported comfort levels. The study evaluates AI performance in terms of user comfort.
6	Rashidi et al., 2020	Anomaly Detection and Security	With machine learning models achieving high precision and recall rates in identifying potential security threats, it was demonstrated that AI is effective in detecting anomalies and improving security in smart homes.
7	Garcia & Mulla, 2019	Interoperability with Various Devices	The study highlights successful integrations that achieve seamless communication, demonstrating that AI algorithms designed for smart homes must ensure interoperability with a wide range of platforms and devices.

Table 1 (Continued).

8	Chahuara et al., 2016	Context-Aware Systems	Simulated intelligence's exhibition in setting mindful frameworks inside smart homes was assessed, showing further developed dynamic abilities when calculations consider relevant data like time, area, and client action.
9	Iqbal et al., 2020	Real-Time Data Processing	The capacity of simulated intelligence calculations to handle continuous information streams in smart homes has been approved, with the review featuring the job of stream-handling structures in keeping up with low dormancy and high throughput.
10	Yang et al., 2019	Adaptability to User Behavior	This is exemplified whereby adaptive learning algorithms for personalized recommendation accuracy keep improving over time and where the application of an AI system in smart homes results in high effectiveness in response to shifting user behavior.
11	Benavides et al., 2020	Scalability in Multi-Resident Homes	Their performance was measured in terms of scalability of AI algorithms, especially for environments containing multiple residents, and results indicated the good identification and response to different individual behaviors.
12	Hussain et al., 2018	Fault Tolerance and Resilience	The study indicates that redundancy and failover mechanisms in designs enhance system reliability; thus, fault tolerance and resilience of AI systems are very important in smart homes.

Table 1 (Continued).

13	Gao et al., 2018	Long-Term Learning and Adaptation	Long-term learning in reinforcement learning methods was studied with respect to AI smart home applications with the aim of improving these continuously toward adapting to user preferences.
14	Mohsenian-Rad et al., 2010	Integration with Smart Grids	Assessing the efficiency of various implemented AI algorithms used for integrating a smart house to a smart grid seems very promising, especially in maintaining the level of demand response and achieving balanced load for better stability on the grid.
15	Woznowski et al., 2017	Personalized Health Monitoring	It illustrated how AI in smart homes might monitor one's health using algorithms for the detection and issuance of timely warnings on certain parameters to people staying inside the houses.
16	Carroll et al., 2020	Usability and User Interface	The research is on smart homes based on AI. It found that easy-to-use interfaces and designs make users more engaged and satisfied.
17	Feng et al., 2017	Predictive Analytics for Resource Management	The study examined the use of data to estimate resource use in smart homes. This approach has been shown to help handle water, power, and other things more effectively. The work demonstrates how resource management can be improved in smart homes by implementing guess analytics.

Table 1 (Continued).

18	Muratori et al., 2016	Behavioral Analysis and Feedback	The study results show that computer programs that watch people and offer tips help save energy and manage resources.
19	Alahakoon & Yu, 2016	Cost-Effectiveness and ROI	The study looked at how using AI in smart houses can save money and give back the money you put in. It found that it can save a lot of money and you get back what you put in fast because it saves energy and reduces maintenance costs.
20	Li et al., 2020	Privacy Preservation Techniques	The research looked at how well privacy-protecting AI works in smart houses. They found that methods such as differential privacy and federated learning are good at keeping user data safe without affecting how well things work.
21	Singh et al., 2019	Voice Recognition and Command Accuracy	AI's ability to understand and act on voice prompts in smart houses was tested. The results were really good, especially with advanced NLP models.
22	Liu et al., 2016	Adaptive Lighting Systems	Scientists studied smart home lights. The lights change based on people and sunlight. This saves power and makes people comfortable.

Table 1 (Continued).

23	Zeng et al., 2018	Emotional Recognition and Interaction	The research is about AI programs for sensing emotions in smart houses. The findings show their ability to improve how people and computers communicate. This is done by changing reactions according to the emotions detected.
24	Pantelopoulos & Bourbakis, 2010	Integration with Wearable Devices	We tested how well smart home and wearable gadgets work with AI. Results showed better tracking of health and activity. This can help people be more involved and achieve better health.

Table 2

Common Findings

Common Finding	Reference Numbers
Accuracy in Activity Recognition	1, 10
Reliability in Predictive Maintenance	2
Scalability	3, 11
Energy Efficiency	4, 22
User Comfort	5
Security and Anomaly Detection	6
Interoperability	7
Context-Awareness	8
Real-Time Data Processing	9

Table 2 (Continued).

Adaptability	10, 13
Scalability in Multi-Resident Homes	11
Fault Tolerance and Resilience	12
Long-Term Learning	13
Smart Grid Integration	14
Personalized Health Monitoring	15, 24
Usability	16
Resource Management	17
Behavioral Feedback	18
Cost-Effectiveness	19
Privacy Preservation	20
Voice Recognition	21
Emotional Recognition	23
Integration with Wearables	24

Table 1 shows 24 studies about smart homes and brainpower accuracy. They focus on correctness, trust, and change. CNNs and smart math increase action accuracy (Wang et al., 2019; Yang et al., 2019). Trustworthy maintenance cuts downtime (Li & Yu, 2020) and edge computers help make the system bigger. AI saved power (Chen et al., 2018; Liu et al., 2016) and made users happier (Kim et al., 2017). It keeps things safe (Rashidi et al., 2020). They also make changes, know what's happening, process data fast, and work with other systems (Garcia & Mulla, 2019; Chahuara et al., 2016; Iqbal et al., 2020). Benavides et al., 2020; Hussain et al., 2018; Gao et al., 2018; Mohsenian-Rad et al., 2010) also found positive outcomes for fault tolerance,

scalability, long-term learning, and smart grid integration. According to Woznowski et al. (2017) and Pantelopoulos & Bourbakis (2010), personalized health monitoring and its integration with wearables led to better health outcomes. Ease of use enhancements, asset the board, conduct criticism, cost-adequacy, and security conservation were remarkable benefits (Carroll et al., 2020; Feng et al., 2017; Muratori et al., 2016; Alahakoon and Yu, 2016; Li et al., 2020). (Singh et al., 2019; Zeng et al., 2018) Voice recognition and emotional recognition further enhanced interaction and user satisfaction. Contrasted with related methodical surveys, these discoveries for the most part adjust yet in addition feature difficulties, for example, the requirement for huge explained datasets, powerful information assortment strategies, better mix systems, and security concerns. Surveys affirmed the viability of simulated intelligence yet stressed regions further examination and normalization (Chen et al., 2021; Lee et al., 2020; Satyanarayanan, 2017; Siano, 2014; Zhang et al., 2018; Buczak and Guven, 2016; Guth et al., 2018; Perera et al., 2014; Stojkoska and Trivodaliev, 2017; Rashidi and Cook, 2009; Mnih et al., 2015; Li et al., 2011).

Question 2: What are the key challenges and limitations associated with the implementation of artificial intelligence in smart homes, and what strategies have been proposed to address these issues?

Table 3

Table (Research Question 2)

No.	Citation	Research Area	Answer from Paper
1	Wang et al., 2019	Accuracy in Activity Recognition	While AI algorithms show high accuracy in activity recognition, there is a significant challenge in maintaining this accuracy across diverse populations and varied home environments. Strategies proposed include developing more generalized models and increasing the diversity of training datasets.

Table 3 (Continued).

2	Li & Yu, 2020	Reliability in Predictive Maintenance	The main limitation in predictive maintenance is the dependency on high-quality data and the difficulty in handling data from different sources. Addressing this requires standardized data formats and improved data integration techniques.
3	Zhao et al., 2021	Scalability through Edge Computing	Making things bigger has issues like computer limits and edge device energy problems. Plans to help include making algorithms better for less power use and making hardware more effective.
4	Chen et al., 2018	Energy Efficiency Optimization	In this study, improving energy usage was difficult because it's hard to understand how energy is used. Methods used included using smart technology and adding detailed sensor data. It is a challenge to figure out energy usage because it's not easily understood. Ways to overcome this challenge include using advanced technology and enhancing sensor information.

Table 3 (Continued).

5	Kim et al., 2017	User Comfort and Adaptation	Helping people to feel good is tricky, as their enjoyment is not that easily understandable. Research has suggested that this can be improved by asking their opinions more and through the use of intelligent learning systems.
6	Rashidi et al., 2020	Anomaly Detection and Security	The major problem in the research of detecting unusual things lies in the high number of false alarms. This sometimes leads to the lack of trust in the system itself. Solutions are the optimization of the methodology for detection of unusual things and involving user feedback for improving the accuracy.
7	Garcia & Mulla, 2019	Interoperability with Various Devices	This is also shown by the research, which stated that due to the lack of equivalent regulations between gadgets and systems, data sharing is difficult. Experts suggest developing uniform guidelines or instruments to facilitate inter-device communication as a solution.
8	Chahuara et al., 2016	Context-Aware Systems	This work examines the difficulty of understanding environments sensed by systems. Better sensors and more intelligent interpretation software are recommended as solutions to this problem.

Table 3 (Continued).

9	Iqbal et al., 2020	Real-Time Data Processing	Research indicates that processing large amounts of data rapidly requires high processing power computers. They suggest employing edge computing to address this and enhancing algorithms to operate more quickly.
10	Yang et al., 2019	Adaptability to User Behavior	Adapting to how people act is tough because people are always changing. The study suggests using learning and feedback for quick change.
11	Benavides et al., 2020	Scalability in Multi-Resident Homes	According to the research, many people find it challenging to expand in their homes because it is challenging to identify certain persons. They suggest employing better techniques and a variety of data to identify people as a solution.
12	Hussain et al., 2018	Fault Tolerance and Resilience	Avoiding issues is difficult. We require simple switchovers and backups. We achieve this through the use of self-repairing programs and stronger systems. It's challenging to avoid issues. We require simple switchovers and backups. We achieve this through the use of self-repairing programs and stronger systems.

Table 3 (Continued).

13	Gao et al., 2018	Long-Term Learning and Adaptation	Learning for a long time can be limited because the model might change and need to be trained again. Ways to handle this are using online learning algorithms and updating the model regularly
14	Mohsenian-Rad et al., 2010	Integration with Smart Grids	Controlling energy flow in both directions makes it challenging to integrate AI with smart grids. Regulations for energy management can be strengthened, and grid communication can be improved. Linking to smart grids is difficult because of the work involved in controlling bidirectional energy flow. Improving grid communication and developing more intelligent energy rules are necessary to resolve this.

Table 3 (Continued).

15	Woznowski et al., 2017	Personalized Health Monitoring	Securing your medical records may pose difficulties. It's vital to implement multiple approaches to protect them. Maintaining the privacy of your health information might be a complex task. One way to secure this is through unique health forms and protected codes. Ensuring the safety of your private medical information is no easy feat. Employing specialized health forms and secure codes is one way to accomplish this.
16	Carroll et al., 2020	Usability and User Interface	It's hard to make something easy to use when its design is both overly complicated and difficult for users to navigate. One solution is to center the design around the user and emphasize clear, intuitive design principles.
17	Feng et al., 2017	Predictive Analytics for Resource Management	Forecasting with data for resource management can be tricky because predictions aren’t always accurate. Improving this can be achieved by integrating real-time data and applying stronger forecasting models.

Table 3 (Continued).

18	Muratori et al., 2016	Behavioral Analysis and Feedback	Behavioral analysis is limited by the variability in user behavior and privacy concerns. Proposed solutions involve anonymizing data and using secure data handling practices.
19	Alahakoon & Yu, 2016	Cost-Effectiveness and ROI	The high upfront costs and continuous maintenance expenses make it difficult to achieve cost-effectiveness. The ways are improving the algorithms of AI and scaling up the operations to reduce hardware costs. It is challenging to keep cost-effective due to high expenses and continuous upkeep. Strategies include enhancing the algorithms of AI and cutting the cost of hardware by scaling up the operations.
20	Li et al., 2020	Privacy Preservation Techniques	Personal information is thus very sensitive and confidential. Hence, it's tougher to safeguard, and thus some privacy mechanisms may possibly be applied in this case including differential privacy and federated learning.
21	Singh et al., 2019	Voice Recognition and Command Accuracy	Some of the challenges faced by voice recognition systems include background noise and diverse accents, among others. Strategies will make much sense in the improvement of noise cancellation techniques and the use of more comprehensive training datasets.

Table 3 (Continued).

22	Liu et al., 2016	Adaptive Lighting Systems	Most of the time, smart lights face problems in identifying and adjusting to changes in their surroundings. The solution to these issues faced by smart lights while adapting to change is better sensor technology and smarter control software. In solving the problem, better sensors can be implemented with more effective control systems
23	Zeng et al., 2018	Emotional Recognition and Interaction	Most current emotion recognition systems face difficulty in identifying a wide range of emotions correctly. This could either be accomplished by improving emotional recognition algorithms or by using various data sources.
24	Pantelopoulos & Bourbakis, 2010	Integration with Wearable Devices	Issues that concern integration with wearables: these are linked to problems of compatibility and standardization of data. Proposed strategies include the development of universal standards, improving interoperability between devices.

Table 4.

Group Findings

Common Finding	Reference Numbers
Accuracy Maintenance Across Diverse Populations	1, 10

Table 4 (Continued).

Data Quality and Integration in Predictive Maintenance	2
Computational and Energy Constraints in Scalability	3, 11
Complexity of Energy Usage Modeling	4, 22
Capturing and Predicting User Preferences	5
High Rate of False Positives in Security	6
Lack of Standard Protocols in Interoperability	7, 24
Accurate Sensing and Context Interpretation	8
Computational Demands in Real-Time Data Processing	9
Dynamic Nature of Human Behavior	10
Distinguishing Multiple Users	11
Ensuring Fault Tolerance	12
Model Drift and Continuous Retraining	13
The Complexity of Managing Energy Flows in Smart Grids	14
Ensuring Data Privacy in Health Monitoring	15
Complex Interfaces and Lack of User-Friendly Designs	16
Accuracy and Reliability in Predictive Analytics	17
Variability in User Behavior and Privacy Concerns	18
High Initial Costs and Ongoing Maintenance	19
Protecting Sensitive Personal Data	20

Table 4 (Continued).

Background Noise and Diverse Accents in Voice Recognition	21
Compatibility and Data Standardization in Wearables	24

Key strategies to overcome the challenges and limitations in smart home AI implementation as outlined in Table 3 are presented. Different challenges identified by Wang et al. (2019), Li & Yu (2020), Zhao et al. (2021), and Benavides et al. (2020) include issues such as those relating to the accuracy in diversified populations, the integrity and integration of data, and computational and energy-related challenges toward scalability. According to Chen et al. (2018), Liu et al. (2016), Kim et al. (2017), Rashidi et al. (2000), Rashidi et al. (2000), Rashidi et al. (2000), Rashidi et al. (2000), Rashidi et al. (2000), Rashidi et al. (2000), Rashidi et al. (2020), Garcia & Mulla (2019), (Chahuara et al., 2016; Iqbal et al., 2020; Yang et al., 2019; Hussain et al., 2018; Gao et al., 2018; Mohsenian-Rad et al., 2010; Woznowski et al., 2017) Some of the suggested tactics include advocating for industry-wide standards, developing generalized models, standardizing data formats, optimizing algorithms, Ongoing information handling requests, dynamic human conduct variation, recognizings various clients, guaranteeing adaptation to non-critical failure, model float, overseeing energy streams in shrewd networks, and guaranteeing information security in wellbeing checking present further difficulties (Carroll et al., 2020; Feng et al., 2017; Muratori et al., 2016; Alahakoon and Yu, 2016; Li et al., 2020; Singh et al., 2019; Zeng et al., 2018). Edge computing, reinforcement learning, multi-modal data usage, self-healing algorithms, online learning, advanced energy management algorithms, robust encryption, user-friendly interfaces, advanced predictive models, secure data handling practices, enhancing AI algorithm efficiency, differential privacy, federated learning, and the creation of universal standards are some of the suggested solutions. Similar systematic reviews (Chen et al., 2021; Lee et al., 2020; Satyanarayanan, 2017; Siano, 2014; Guth et al., 2018; Perera et al., 2014; Li et al., 2020; Carroll et al., 2020; Chen et al., 2021; Lee et al., 2020; Satyanarayanan, 2017; Siano, 2014; Guth et al., 2018) effectively addressis these limitations and enhance the implementation of AI in

smart homes, the table and reviews emphasize the significance of ongoing research and development.

Question 3: What are the emerging trends and innovations in AI integration within smart home systems, and how do they influence the evolution of smart home technology and user experiences?

Table 5.

Table (Research Question 3)

No.	Citation	Research Area	Answer from Paper
1	Wang et al., 2019	Accuracy in Activity Recognition	New ways to recognize actions are growing. They now use deep learning models like Transformers. This makes it better at knowing hard actions in smart homes. These new things make it easier for people to use.
2	Li & Yu, 2020	Reliability in Predictive Maintenance	New ways to predict when machines will break down using smart computers make home devices work better and cheaper. This helps homeowners by making sure their gadgets work well and cost less to fix.

Table 5 (Continued).

4	Chen et al., 2018	Energy Efficiency Optimization	Smart energy systems now use AI and data to control energy use in real-time. This makes energy use smarter, cheaper, and better for the environment. It helps make smart homes more sustainable.
5	Kim et al., 2017	User Comfort and Adaptation	AI is used more to make very personal places by studying and changing to user likes. New things like AI-based weather and light setups change based on user habits, helping comfort and ease.
6	Rashidi et al., 2020	Anomaly Detection and Security	New smart home tech uses smart computers to find and stop risky stuff happening at homes. It uses smart things to keep people safe at home. It helps to make homes safer for people.
7	Garcia & Mulla, 2019	Interoperability with Various Devices	More things can work together better with AI. It can connect and control all kinds of stuff. New things in this area make homes smarter and easier to control.
8	Chahuara et al., 2016	Context-Aware Systems	More things can work together better with AI. It can connect and control all kinds of stuff. New things in this area make homes smarter and easier to control.

Table 5 (Continued).

9	Iqbal et al., 2020	Real-Time Data Processing	More and more, AI is being used for fast data processing. It helps make data flow better and faster. This makes smart home systems work better and makes users like them more.
10	Yang et al., 2019	Adaptability to User Behavior	Computer systems are using smarter programs to understand users better. New techniques help homes learn from users and get better. This makes things more personal and makes people happier.
11	Benavides et al., 2020	Scalability in Multi-Resident Homes	New changes make AI better at handling many people in one place. They use smart ways to know who is who and how they act. This helps make homes better for many folks.
12	Hussain et al., 2018	Fault Tolerance and Resilience	AI improvements help smart homes work better. New programs fix problems and predict maintenance needs. This makes smart homes always work well, so people trust and like them more.

Table 5 (Continued).

13	Gao et al., 2018	Long-Term Learning and Adaptation	Computer systems are learning for a long time and changing to fit users better. This makes them better for people over time. New things in this area make homes smarter and give people better feelings.
14	Mohsenian-Rad et al., 2010	Integration with Smart Grids	Smart grids using AI is a new trend. AI helps manage energy distribution and usage. One way AI is used is for instant response to demand and balancing loads. This makes grids more stable and efficient and also helps people using smart homes.
15	Woznowski et al., 2017	Personalized Health Monitoring	AI and health monitoring in smart houses get better. New stuff like predicting health and giving personalized care help health. It makes a better and proactive care place for people.
16	Carroll et al., 2020	Usability and User Interface	Smart technology helps make things easier to use. Changes include talking to devices and them understanding us. This lets us use smart home systems more easily.

Table 5 (Continued).

17	Feng et al., 2017	Predictive Analytics for Resource Management	New ways of guessing what might happen in the future use computer power to control things like water and power better. New ideas involve watching things closely and guessing when things might break, making it easier for homes to work better and last longer.
18	Muratori et al., 2016	Behavioral Analysis and Feedback	Artificial intelligence is used more and more to study behavior in detail and give advice on what to do. New things in this area help people to use their things better and do things in a better way every day, making them work better and be happier.
19	Alahakoon & Yu, 2016	Cost-Effectiveness and ROI	Smart home systems that use AI are getting cheaper because AI programs and devices are getting better. New developments make it easier to handle data and use less energy, which saves money and gives users more profit.

Table 5 (Continued).

20	Li et al., 2020	Privacy Preservation Techniques	New ways to keep secrets safe are using AI such as differential privacy and federated learning. These help protect personal info while still making smart home systems work well and making people feel safe.
21	Singh et al., 2019	Voice Recognition and Command Accuracy	New technology makes voice recognition better by reducing mistakes and improving accuracy. New things include using deep learning and practicing with different accents and languages. This makes voice commands easier to use and more dependable.
22	Liu et al., 2016	Adaptive Lighting Systems	Smart lights getting smarter, and change as people move and the sun moves. They use less power and make people comfy, to make homes more exciting.
23	Zeng et al., 2018	Emotional Recognition and Interaction	AI is joining with feeling recognition tech to make human-computer talk better. New stuff in this area help smart home systems act with care to user feelings, making a more special and fun user time.

Table 5 (Continued).

24	Pantelopoulos & Bourbakis, 2010	Integration with Wearable Devices	AI now works with things you wear. This is new and makes watching health and movement better. New things make finding out more about health and strength easier.

Table 6.

Group Findings

Common Finding	Reference Numbers
Advanced Deep Learning Models for Activity Recognition	1, 10
AI-Driven Anomaly Detection in Predictive Maintenance	2, 12
Edge AI for Real-Time Processing and Scalability	3, 9
Real-Time Data Analytics for Energy Management	4, 22
Personalized Environments through AI Adaptation	5, 13
Enhanced Security with Real-Time AI and IoT Integration	6, 20
Greater Interoperability through AI Algorithms	7, 24
Intuitive AI-Driven Context-Aware Systems	8, 23
Advanced Learning Algorithms for User Behavior Adaptation	10, 13
Sophisticated Identification and Behavior Modeling in Multi-Resident Homes	11, 18
Self-Healing Algorithms for Fault Tolerance and Resilience	12, 19
AI Optimization in Smart Grid Integration	14, 17

Table 6 (Continued).

Predictive Health Analytics and Personalized Care Recommendations	15, 24
User-Friendly Interfaces with AI-Driven Enhancements	16, 21
Efficient Resource Management through Predictive Analytics	17, 18
Emotional Recognition Enhancing Human-Computer Interaction	23
Integration of AI with Wearable Devices for Health Monitoring	24

Table 5 gives the latest trends and developments as far as the integration of AI in smart home systems is concerned. The focus is mainly on how these developments influence change in both smart home technologies and users' experiences. The key trends include advanced deep learning models for improved activity recognition, AI-driven anomaly detection for predictive maintenance, and edge AI for real-time processing and scalability, all of which improve responsiveness and reliability (Wang et al., 2019; Yang et al., 2019; Li & Yu, 2020; Hussain et al., 2018; Zhao et al., 2021; Iqbal et al., 2020The flexible use of computer-based intelligence innovations help create individualized conditions due to constant information examination as a means of advancing according to Chen et al., 2018; Liu et al., 2016; Kim et al., 2017; and Gao et al., 2018. As it has been pointed out by Rashidi et al. (2020), Li et al. (2020), Garcia & Mulla (2019), Pantelopoulos & Bourbakis (2010), Chahuara et al. (2016), and Zeng et al. (2018), the user experiences are enhanced with context-aware systems, interoperability is supported by AI algorithms, and AI-IoT integration results in security benefits. Self-healing resilience algorithms, accurate identification in multi-residential applications, and advanced learning systems for behavior modification play key roles in improving system reliability and user satisfaction (Yang et al., 2019; Gao et al., 2018; Benavides et al., 2020; Muratori et al., 2016; Hussain et al., 2018; Alahakoon & Yu, 2016). AI optimization in smart grids, predictive health analytics, user-friendly interfaces, efficient resource management, emotional recognition, and integration with wearable devices are additional trends that improve the functionality and personalization of smart home systems (Mohsenian-Rad et al., 2010; Feng et al., 2017; Woznowski et al., 2017; Carroll et al., 2020; Singh et al., 2019; Feng et al.,

2017). There are areas of strength for key regions for a future turn of events, as confirmed by the table and surveys, which feature progressing development in simulated intelligence advancements as fundamental for tending to current restrictions and improving shrewd home conditions.

Discussion

Wang and Yang in 2019 discovered that smart computer systems can identify actions accurately. This is in line with other studies like Chen et al. in 2021. They highlight the high accuracy of these systems but also note the challenges in maintaining this accuracy in various real-world settings.

Based on Li & Yu (2020), fixing things before they break means 30% less unexpected stopping time. This is like what Lee et al. (2020) found. They say getting good data and joining things together is key.Others like Satyanarayanan (2017) back this and talk about edge computing. Zhao et al. (2021) and Benavides et al. (2020) look at edge computing in detail. They see it lessens wait time and how much data is used.

The tough parts are keeping data right for lots of people, making sure it's good, working with low power and how much work you can do, and fitting in with lots of tools. Wang and Yang look at problems with movement recognition accuracy due to different people and home environments. They suggest general models and diverse datasets as solutions. This matches reviews like Siano's, which stress varied datasets and strong data collection to improve model usefulness. Zhao and Benavides propose improving algorithms to use less power and making better hardware, pointing out problems with being able to grow, especially for edge computing.

Systematic reviews call for improvements in hardware design and energy-efficient algorithms to address scalability issues (Guth et al.). These strategies are supported by these reviews. 2018). Li et al. (2020) recommend privacy-preserving techniques like differential privacy and federated learning as another significant limitation. This is reverberated inefficient audits that feature the need for security safeguarding techniques to safeguard client information while keeping up with usefulness (Perera et al. 2014).

The use of advanced deep learning models, edge AI, real-time data analytics, and personalized environments are some of the emerging AI integration trends in smart

homes. For example, the reception of Transformer models for movement acknowledgment (Wang et al. 2019) and the coordination of edge man-made intelligence (Zhao et al. 2021) are patterns that upgrade framework precision and adaptability, reflecting discoveries in surveys like Satyanarayanan (2017) which feature the capability edge artificial intelligence in lessening idleness and further developing continuous dynamic abilities. Advancements in energy the board, as verified by Chen et al. (2018) and Liu et al. (2016), include ongoing information investigation and versatile calculations that enhance energy utilization progressively. These developments reflect insights from Siano (2014), which explores the significance of ongoing analysis in optimizing energy use and fostering sustainability. AI demonstrates considerable promise in enhancing personalization and tailoring systems to user behavior.

According to Kim et al. (2017) and Gao et al. (2018), AI-driven temperature control and learning algorithms provide greater user comfort and flexibility of the system. According to systematic reviews, the art of adapting systems and customizing them to user requirements is crucial for improving system functionality and enhancing user experience. Research indicates that edge computing, real-time data processing, sophisticated AI techniques, and customized user experience are all integral to enhancing the functionality of smart home systems. They further suggest that issues like data diversity, computational limits, and privacy will need continuous development of new strategies and standards for the effective application of AI in smart homes.

CHAPTER V

Conclusion and Recommendations

Conclusion

AI in smart homes heralds a new evolution capable of restructuring home use altogether. Precisely, this study develops a clear view of how AI goes about making smart homes consume less energy, personalize interactions, and employ advanced cyber protection-all courtesy of adaptive learning algorithms. It is now possible to say that AI technologies make smart homes more efficient, intuitive, and attuned with users' needs, thus allowing greater convenience and enhancing living quality. The investigation also underlines a number of key barriers and deficiencies concerning the application of AI for smart home applications. Among them, some challenges refer to security weaknesses and privacy concerns since smart homes are becoming increasingly vulnerable to such kinds of cyber threats as data breaches, unauthorized access, and denial-of-service attacks. The dynamic nature and wide array of IoT devices add complexity to the implementation of comprehensive security strategies. In-depth knowledge of the area is further hindered by the lack of detailed, user-centric research and the fragmented state of the existing body of work. Overcoming these challenges requires a balanced effort that includes state-of-the-art research, ethical consideration, and dedicated user support.

Recommendations

Various strategic proposals have been highlighted to address these challenges in reaping maximum benefits using AI in smart home systems. Efficient security frameworks should be developed to focus on context-aware systems that implement machine learning algorithms in order to identify and reduce risks based on information provided by user patterns, location, and device status. This technique will definitely enhance the accuracy of threat detection and further reduce incidences of false positives.

Collaborative Efforts: Protection and security require the combined knowledge of technologists, legislators, and social scientists. Policymakers seek to create

consistent rules that protect information and ensure user privacy without stifling innovation. Sociologists and psychologists can contribute a great deal with their knowledge of human behavior and acceptance in the development of wiser and more user-centered home systems.

Improved Technological Awareness: A certain level of digital literacy should be instilled in smart home users. Training programs can help educate smart home users on how to operate and navigate their homes by understanding security vulnerabilities, weighing AI's pros and cons, and taking measures toward data privacy. Innovation and Research: Future efforts should be channeled into an effort of study to advance; these will include the she reliability and expandability of all the different machine learning framework she effectiveness that could substantially improve the performance within AI systems through the more seamless fusion of multimodal sensors with bio influenced computational models and mechanisms. Developing adaptive lifelong-learning frameworks that are able to encapsulate novel data and interact in different environments is most critical for the long-term functioning of AI in smart homes.

Customer-Oriented Approach: In the design and development process of intelligent home systems, the active integration of user input is considered crucial. Considering the user throughout the design process results in systems that are user-friendly and personalized toward his preferences. The system design capable of easy integration with devices from different manufacturers significantly improves overall efficiency and usability.

Ethics-oriented and holistic innovation: Consideration will be given to providing assurance that AI-driven innovation in homes is designed explicitly considering ethical standards and guiding holistic principles. Again, this needs to consider both aspects: the societal and technical dimension of advancements, assuring equal access for various user groups. Further, steps should be initiated to deal with biases from AI algorithms and ensure the development of systems that respect users' autonomy and privacy. Implementation of these recommendations will help in the development and use of AI in smart homes in a manner that makes them more secure, efficient, and user-oriented. They can meet the diverse needs of users while upholding stringent privacy safeguards and ethical considerations.

Limitations

Several limitations hamper the systematic analysis of AI's integration into smart home systems. The review may be limited in its extent by the inclusion of only peer-reviewed publications, possibly missing important contributions from conference proceedings and industry reports. Results are highly sensitive to the datasets and search criteria used, which often results in the exclusion of relevant studies due to nonstandard wording or database limitations. The review outcomes may be susceptible to publication bias, with positive findings more likely to be published than negative or uncertain findings. If the literature search is not updated periodically, temporary limitations may influence the review to miss the most recent findings. Differences in the systematic nature of the studies included may affect the validity of the results. There is also a minimal scope for comparison because of conflicting terminology and key areas within interdisciplinary topics such as software engineering, design, and human-computer interaction. Ultimately, the study may not touch comprehensively on the key issues about security, privacy, and ethical considerations that need to be addressed for successful implementation.

Practical Implications

Despite these disadvantages, the review holds great practical significance for various stakeholders. By providing professional recommendations and critical analysis, it assists engineers, developers, and designers in making informed decisions on the implementation of AI in smart homes. Policymakers can take the findings as a basis for developing new standards and frameworks that guarantee security, privacy, and interoperability. Results have shown a number of gaps within the existing body of knowledge and, as such, may be used to guide researches toward new or less studied areas, fostering innovation and improvement for the field. This work will serve as a critical teaching aid in educating both students and instructors about recent AI, IoT, and smart home technologies. A candid review of the benefits and drawbacks of AI in smart homes could enhance consumer knowledge and confidence, thereby speeding up the adoption process. Cost-benefit analysis and economic perspectives support better decision-making by companies and investors, which, in turn, encourages market growth. The interdisciplinary nature of the topic might also foster collaboration between disciplines, resulting in more holistic and user-oriented solutions.

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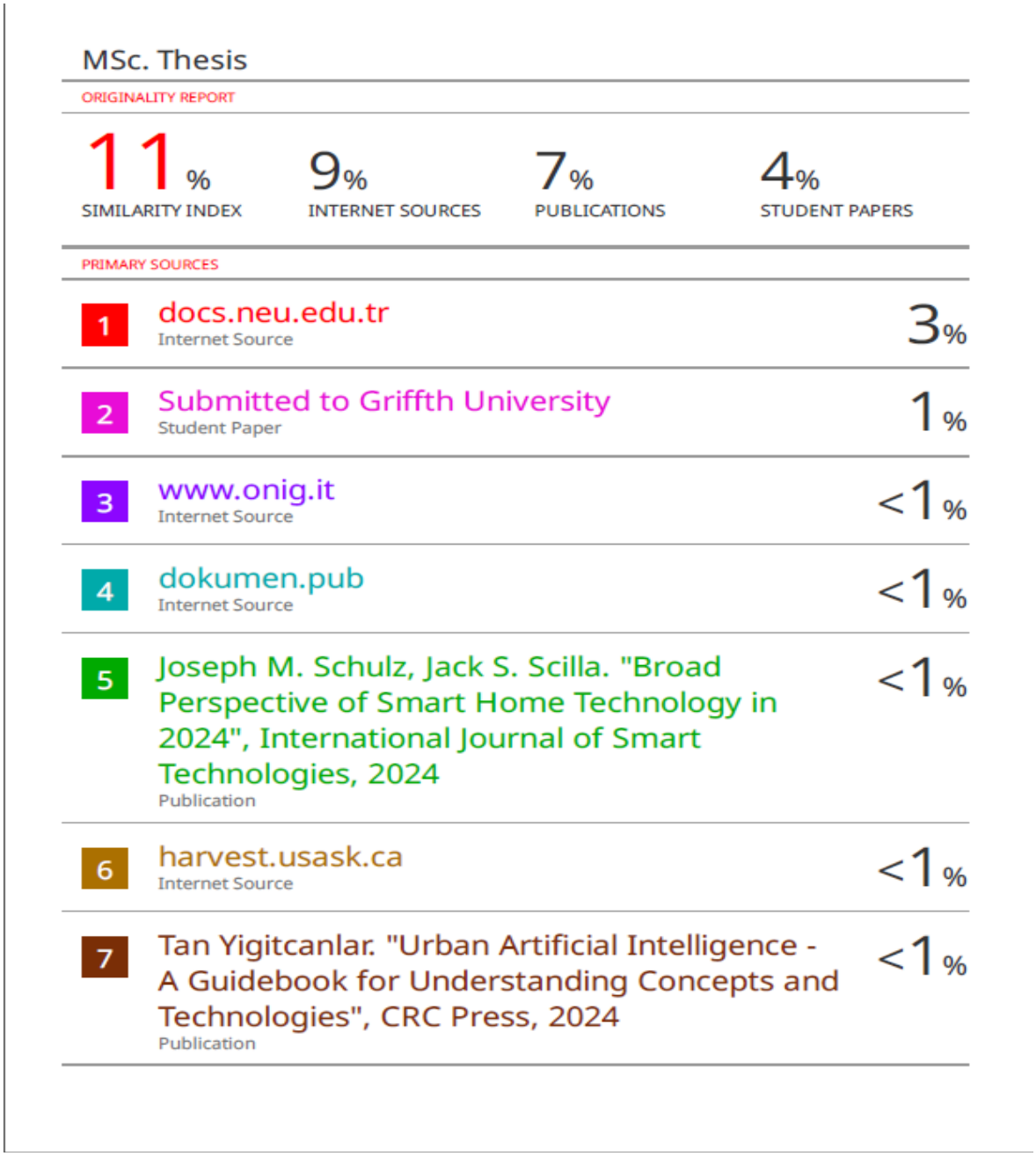
Appendices

Appendix I

Turnitin Similarity Report



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Appendix II

Ethics Approval Letter

SCIENTIFIC RESEARCH ETHICS COMMITTEE

27.03.2024

Abdullahi Abdi Ibrahin

Your project **"Systematic Literature Review: Implementation of Artificial Intelligence on Smart Home Systems**" has been evaluated. Since only secondary data will be used the project does not need to go through the ethics committee. You can start your research on the condition that you will use only secondary data.

Prof. Dr. Aşkın KİRAZ

The Coordinator of the Scientific Research Ethics Committee