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IMPLEMENTATION OF A SMART HOME SYSTEM USING IOT WITH GOOGLE NEST INTEGRATION FOR LIGHTING AND SECURITY CONTROL

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ABSTRACT

This research explores the implementation of a smart home system using the Internet of Things (IoT) with Google Nest as a voice-command interface to control lighting and CCTV in residential environments. The system integrates smart touchscreen light switches and IP-based surveillance cameras within the Google Home ecosystem. Through design, installation, and user testing, the system was evaluated for functionality, convenience, and user satisfaction. The study found that voice control enhanced accessibility, while touchscreen switches offered practical manual control when needed. Real-time CCTV monitoring via IP cameras provided added home security. However, challenges such as internet dependency and post-blackout functionality of smart devices were identified. Overall, the research demonstrates the feasibility and benefits of integrating IoT in modern homes and presents a user-friendly model that could inform future smart residential designs. The findings were also validated through practical implementation, as documented in a video published by Herlian Architecture Studio.

KEYWORDS: google nest, home automation, IoT (internet of things), IP camera, smart home, touchscreen switches, voice control

Penelitian ini mengeksplorasi penerapan sistem smart home menggunakan Internet of Things (IoT) dengan Google Nest sebagai antarmuka perintah suara untuk mengontrol pencahayaan dan CCTV di lingkungan rumah tinggal. Sistem ini mengintegrasikan saklar lampu layar sentuh pintar dan kamera pengawas berbasis IP dalam ekosistem Google Home. Melalui proses perancangan, instalasi, dan pengujian pengguna, sistem dievaluasi berdasarkan fungsionalitas, kenyamanan, dan tingkat kepuasan pengguna. Hasil penelitian menunjukkan bahwa kontrol suara meningkatkan aksesibilitas, sementara saklar layar sentuh memberikan kontrol manual yang praktis saat dibutuhkan. Pemantauan CCTV secara real-time melalui kamera IP juga memberikan peningkatan keamanan di rumah. Namun, beberapa tantangan seperti ketergantungan pada koneksi internet dan keterbatasan perangkat setelah pemadaman listrik turut diidentifikasi. Secara keseluruhan, penelitian ini menunjukkan bahwa integrasi IoT dalam hunian modern sangat layak dan memberikan berbagai manfaat, serta menghadirkan model sistem yang ramah pengguna dan dapat menjadi referensi untuk desain rumah pintar di masa depan. Temuan ini juga divalidasi melalui implementasi langsung yang didokumentasikan dalam video oleh Herlian Architecture Studio.

KATA KUNCI: *google nest, otomatisasi rumah, internet of things (IoT), kamera IP, rumah pintar, saklar sentuh, kontrol suara*

INTRODUCTION

In recent years, the rapid evolution of digital technologies has catalyzed a transformative shift in residential living through the emergence of the smart home. A smart home refers to a residence equipped with IoT-enabled devices that allow remote monitoring, control, and automation of household systems. These systems include lighting, security, HVAC, and entertainment, all accessible through smartphones, voice commands, or automated routines. The systems that are going to be used in home robotization join those in structural computerization, similarly to the control of private activities (Kirola et al., 2019). This transformation not only improves convenience but also enhances safety, energy efficiency, and accessibility for users of all ages and physical capabilities.

Intelligent and effective use of IoT technology can provide greater comfort and security at home, and can optimize the daily living experience (Supiyandi et al., 2023). The Internet of Things (IoT) is at the center of this change, connecting devices that collect and share data. IoT allows household appliances to operate intelligently and respond dynamically to environmental and user-generated stimuli. The growing affordability and accessibility of smart home technology have made it increasingly viable for middle-income households, expanding its potential impact.

This study focuses on integrating Google Nest as a centralized voice assistant to control key home systems – namely, lighting and surveillance – via both voice commands and touchscreen interfaces. In addition to convenience, this integration enhances security through real-time CCTV monitoring and supports energy conservation by automating lighting control. The study proposes a practical IoT-based smart home framework that is easy to implement, scalable, and user-friendly.

The development of smart homes has accelerated significantly with the advancement of the Internet of Things (IoT), which enables interconnected devices to collect, process, and respond to data autonomously. Smart home environments aim to increase convenience, security, and energy efficiency for residents through automated control systems (Alaa et al., 2017)

IoT frameworks in residential settings typically involve a combination of sensors, actuators, microcontrollers, and cloud-based or local control platforms (Perera et al., 2014). A sensor network is responsible for environmental data acquisition in smart homes (Alam et al., 2012). Devices like Google Nest Hub serve as centralized controllers that use voice recognition and artificial intelligence to interact with other smart appliances, including lighting systems, thermostats, and surveillance cameras (Al-Mushaqbeh & Ghzawi, 2019).

Lighting control is one of the most common applications in smart homes. Touchscreen switches and smart bulbs connected via Wi-Fi or ZigBee protocols allow users to adjust lighting conditions manually or through automation. Several studies have shown that implementing smart lighting systems can lead to improved user experience and significant energy savings (Han et al., 2014; Kashani & Hashemi, 2020).

Security systems are another critical component of smart home ecosystems. The integration of IP-based CCTV cameras and Google Assistant provides real-time surveillance and remote monitoring capabilities (Naranjo & Arias, 2018). The use of motion detection and cloud storage features enhances household safety and situational awareness, which is increasingly essential in modern urban living.

Previous research has also highlighted the challenges of smart home systems, including network dependency, privacy risk, and device interoperability (Lin & Bergman, 2016; Risteska Stojkoska & Trivodaliev, 2017). While platforms like Google Home offer high compatibility, initial configuration and maintenance remain barriers to widespread adoption, especially for non-technical users.

In summary, existing literature supports the use of IoT and voice-assisted systems in smart home applications. However, there remains a need for localized case studies and prototypes that demonstrate how these technologies can be implemented effectively in residential homes – particularly in regions where smart infrastructure is still emerging. This research aims to contribute by showcasing a real-world smart home setup using Google Nest, touchscreen switches, and CCTV systems, evaluated from both technical and user experience perspectives.

METHODS

This research involves the implementation of a smart home prototype incorporating the following components:

1) Google Nest Hub: Serves as the central voice interface for the systems.
2) Smart Touchscreen Light Switches: Installed in various rooms to allow both manual and digital control of lighting systems.
3) IP-based CCTV Cameras: Monitored and controlled via the same Google Nest hub or its associated app.
4) IoT Framework: All devices communicate over a shared home network via Wi-Fi and are managed through the Google Home app.

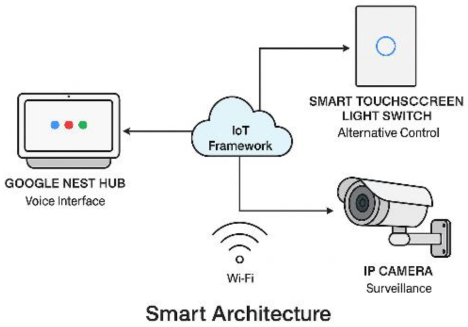

Figure 1. IoT Framework in Smart Home
(Source: Author Document, 2025)

This study adopts an applied research approach to implement and evaluate a prototype smart home system based on Internet of Things (IoT) technologies.

The goal is to integrate multiple components – voice control, manual touchscreen interfaces, and surveillance – into a unified and user-friendly ecosystem. The methodology consists of four key stages: System Design, Component Selection, Implementation, and Testing & Evaluation. Real-time location information alone is not enough for effective building energy and comfort management. This issue is especially true for lighting systems as they affect the user's visual comfort (Nguyen and Aiello, 2013).

1) System Design

   The smart home system architecture was designed around a centralized control framework. The primary control hub, Google Nest Hub, serves as the voice-activated interface. All smart devices were selected for their compatibility with Google Assistant, allowing centralized control via the Google Home app. The overall design emphasizes:

   a) Modularity, allowing the integration of new devices.
   b) Redundancy, by providing both voice and touch control.
   c) Security, through network encryption and local video storage.

2) Component Selection

   The following hardware and software components were chosen based on compatibility, ease of use, and integration ability:

   a) Google Nest Hub: Acts as the central voice assistant and smart display.
   b) Touchscreen Smart Light Switches: These Wi-Fi-enabled switches allow manual and app-based control, with real-time feedback to Google Nest.
   c) IP-based CCTV Cameras: Wireless indoor and outdoor cameras with motion sensors and night vision, integrated into the system via Google Home.
   d) Smartphone with Google Home App: Used to configure, monitor, and control devices remotely.
   e) Wi-Fi Router: Provides 2.4GHz connectivity, required by most smart devices.

3) System Implementation

   Installation and configuration were carried out in a test environment simulating a residential home. Key implementation included:

   a) Hardware Setup: Devices were physically installed in designated areas – light switches in each room, cameras at entry points, and a Google Nest in the living area.
   b) Device Configuration: Each device was paired with the Google Home app and connected to the same network.
   c) Automation Programming: Voice commands were programmed through Google Routines (e.g., "Turn on the A lights" or "Turn off the B light").
   d) Integration Testing: Each function (lighting, CCTV, voice command) was tested independently and then jointly to ensure seamless operation.

4) Testing and Evaluation

   To evaluate the system, we conducted both functional and usability tests:

   a) Functional Testing assessed the responsiveness of voice commands, synchronization between touch and voice controls, and real-time camera streaming.
   b) Usability Testing involved a small group of participants (n=10) who interacted with the system and completed a questionnaire assessing ease of use, reliability, and satisfaction.

RESULTS AND DISCUSSION

The smart home system was successfully implemented in a residential test environment and evaluated across multiple dimensions, including functionality, user experience, system performance, and practical challenges. The principle is Wi-Fi module through Wi-Fi module a web server can be added to the module, which helps in controlling gadgets over the internet (Bhanuabhiram et al., 2019). The integration of Google Nest, touchscreen light switches, and IP-based cameras demonstrated the potential of IoT in enhancing convenience, safety, and operational efficiency in residential homes.

1) System Functionality and Integration

The smart home prototype enabled two primary modes of control:

a) Voice Control via Google Nest Hub

   The voice recognition on electrical equipment using the Google Assistant app on smartphones. The Google Assistant app will accept voice commands when the pronunciation is correct (Isyanto, et al. 2020).

   - "OK Google, turn on the living room lights!"
   - "OK Google, turn off the kitchen lights!"
   - "OK Google, turn on the bedroom lights!"

Figure 2. Installation of Google Nest
(Source: Author's Document, 2025)

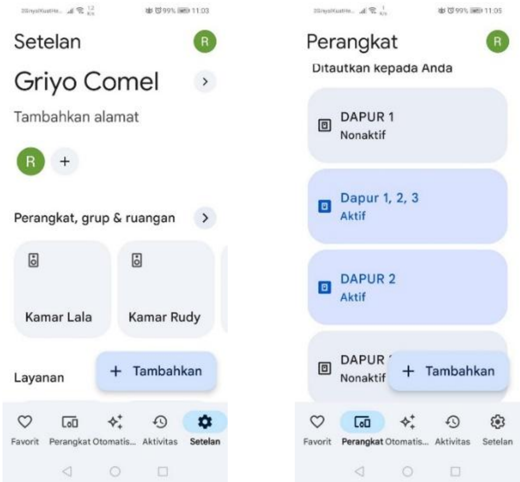

Figure 3. Interface and Setting of Google Home
(Source: Author's Document, 2025)

Voice recognition-based home automation systems are most useful for handicapped and elderly persons, who want to control home appliances by speaking voice commands (Asadullah and Raza, 2016). Those commands were processed using natural language processing (NLP) and executed with average response times of 0.8 to 1.2 seconds, depending on network latency.

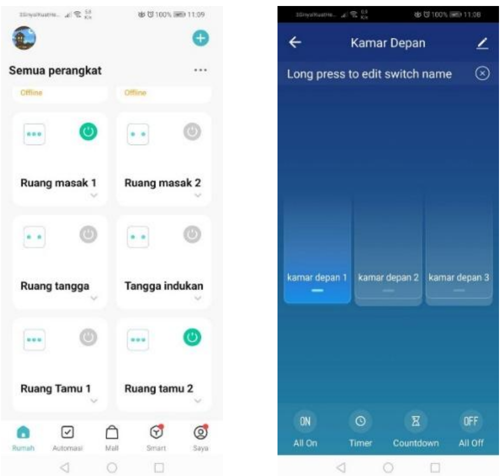

Figure 4. Setting of Lights in Bardi app
(Source: Author's Document, 2025)

Figure 5. Schedule Setting of Lights in Bardi app
(Source: Author's Document, 2025)

b) Manual Control via Touchscreen Light Switches
The touchscreen switches provided a reliable and responsive interface for users who preferred tactile interaction or when voice commands were not feasible (e.g., during noise or internet outages).

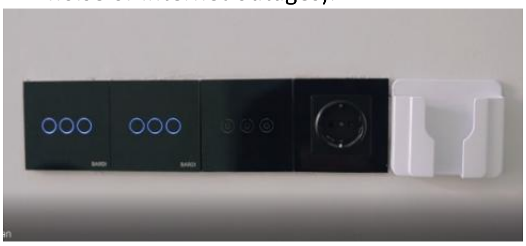

Figure 6. The Touchscreen Switches from Bardi
(Source: Author's Document, 2025)

All devices were connected to the same Wi-Fi network and integrated through the Google Home app, providing a centralized control and monitoring interface.

2) Real-Time CCTV Monitoring

The smart home is a comfortable residence where the consumer can control home appliances remotely from anywhere using internet-connected devices (Elkholy et al., 2022). The CCTV system was composed of multiple IP cameras positioned at strategic points (front door, living room, and backyard). These were configured to:

a) CCTV is placed in the front area of the house, the carport, and the backyard. Stream live video to the V380 Pro app display.

Figure 7. The Installation of CCTV
(Source: Author's Document, 2025)

Figure 8. Stream Video from the V380 Pro app
(Source: Author's Document, 2025)

b) IoT data streams should be handled in a parallel manner to boost the performance of data analytics and to optimize the smart home operations (Yassine et al., 2019). Send motion alerts to the user's phone.

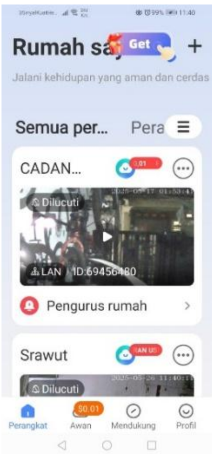

Figure 9. Motion Alerts from the V380 Pro app
(Source: Author's Document, 2025)

c) Another major requirement for dealing with large-scale IoT data from smart homes, is data-relevance through visualization (Yassine et al., 2019). Store video locally and in the cloud.

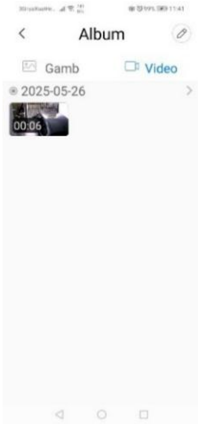

Figure 10. Store Video from the V380 Pro app
(Source: Author's Document, 2025)

This setup significantly improved situational awareness and home security, allowing real-time responses to events or visitors. Because each IoT network provides some time-varying measurements, there is a need to ensure that each message is fresh (Riazul et al., 2015).

3) User Experience and Feedback

A usability study involving 10 family members was conducted. Participants evaluated the system based on ease of use, reliability, and satisfaction. Key findings included:

Table 1. Questionnaire Data

No.	Criterion	Average Score (out of 5)
1.	Ease of Voice Control	4.7
2.	Ease of Touchscreen Use	4.5
3.	System Responsiveness	4.2
4.	Integration & Convenience	4.8
	Overall Satisfaction	**4.6**

Users reported high satisfaction due to the intuitive interaction model (voice + touch) and the modern, clean interfaces of the Google Home ecosystem.

4) Performance and Reliability

a) Connectivity: The system relied heavily on a stable internet connection. In situations of Wi-Fi interruption, voice control was non-functional, although some touchscreen switches retained basic offline functionality.

b) Latency: Minor delays (0.5-1.5 seconds) were occasionally experienced, mostly during peak network traffic.

c) Security: All communications were encrypted via WPA2 protocols. However, regular software updates and password protection were emphasized to maintain security.

d) Emergency: In the event of a power outage, all lights connected to the internet cannot be turned on immediately when the power comes back on. So it is necessary to provide manual lights (standard or manual light switches) so that in an emergency, some can still work or turn on immediately.

5) Limitations and Challenges

Despite the overall success, the system had several limitations:

a) Internet Dependency: Loss of connection disables voice control and real-time video streaming.
b) Initial Configuration Complexity: Setup required a learning curve, particularly in syncing devices and defining routines.
c) Cost: Initial investment in smart devices may be high for some households.

6) Real-World Validation

The implemented system was showcased in a video published on the researcher's YouTube channel, *Herlian Architecture Studio* (https://youtu.be/NiWAOq1JeFY). The video presents a walkthrough of the working smart home system, highlighting lighting control, CCTV integration, and the smooth operation of both voice and touch interfaces.

Figure 11. Demonstration via Youtube page
(Source: Author's Document, 2025)

CONCLUSION

This research has successfully demonstrated the practical implementation and benefits of a smart home system utilizing the Internet of Things (IoT) to control lighting and surveillance in a residential environment. By integrating Google Nest Hub as a voice-controlled interface, smart touchscreen light switches as an alternative manual control, and IP-based CCTV cameras for security monitoring, the system provided a cohesive, responsive, and user-friendly smart home solution.

The experimental results and user feedback revealed that using voice control makes it easier and more convenient to use, especially for older adults or people with disabilities. Touchscreen light switches provide a valuable backup and intuitive alternative when voice control is not suitable (e.g., due to noise or connection issues). IP cameras integrated with the Google ecosystem offer real-time monitoring and alerts, contributing to enhanced household security. The Google Home ecosystem allows centralized control and automation, enabling energy-saving routines and smart scheduling.

Furthermore, the system achieved high scores in user satisfaction, particularly in ease of use, integration, and response time. Despite the promising outcomes, certain challenges such as internet dependency, initial setup complexity, and power outage limitations were identified. For example, smart lighting devices cannot operate immediately after a blackout unless a manual backup is provided, indicating the need for hybrid systems in emergency scenarios.

From a broader perspective, this study supports the growing relevance of IoT in the housing and architectural sectors, particularly in smart urban planning and modern residential designs. The real-world demonstration, as documented in the accompanying YouTube video by *Herlian Architecture Studio*, also affirms the practicality and feasibility of adopting smart technologies in everyday homes.

In conclusion, the integration of IoT devices into home environments is not only technically feasible but also highly beneficial in terms of comfort, security, and energy efficiency. Future development may focus on enhancing system independence from internet availability, incorporating AI-based learning for behavioral automation, and expanding compatibility with additional smart devices to create a more resilient and intelligent living environment.

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