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From lock and key to bits and bytes: Smart home framework integrated for residential homes

[1]Pavana S Reddy, [2]Dr. Nischay and [3]AR Dhanush B

[1]Student, Department of Interior Design, JD Institute, Bangalore, Karnataka, India
[2]HOD, Department of Interior Design, JD Institute, Bangalore, Karnataka, India
[3]Faculty, Department of Interior Design, JD Institute, Bangalore, Karnataka, India

Corresponding Author: Pavana S Reddy

Abstract

The evolution of smart homes has witnessed a shift in the way we interact with and manage our living spaces. Initially driven by convenience and automation, smart homes have progressed to integrate advanced technologies. Innovations enable seamless connectivity and control, allowing users to manage various aspects of their homes remotely. However, this technological leap comes with inherent challenges, particularly in the realms of privacy and security.

As smart homes become more interconnected, the vast amount of personal data generated raises concerns about unauthorized access and misuse. Users are increasingly worried about the potential vulnerabilities associated with smart devices, which could compromise their privacy. Addressing these concerns requires security measures, including encryption, regular software updates, and secure authentication methods.

In conclusion, the evolution of smart homes has brought about convenience, but the simultaneous emphasis on privacy and security is imperative to bring up user trust and ensure the responsible position of these transformative technologies. Smart home devices play a very crucial role in judging the security and privacy of smart homes. Through this research I have explored few devices and I have added suggestions of the devices that could be used.

Keywords: Smart home evolution, security problems, privacy

Introduction

In an era of technological advancement, the concept of home security has been evolved dramatically, transitioning from traditional lock-and-key mechanisms to an intricate network of interconnected devices, known as the smart home. This research paper deals about the multifaceted(multi-functional) relationship between smart homes and human occupants, highlighting the role they play in modern living.

A home is generally called a smart home when it has at least one smart device that is connected to the internet which can be controlled remotely. Smart devices include things like lights, thermostats, locks, security cameras and speakers. Smart homes can make our lives more convenient, comfortable, secure, and energy-efficient, and can improve the quality of our life. A smart home demonstrates the capability to autonomously adapt to the needs and preferences of its inhabitants, thereby enhancing convenience, safety, security and energy efficiency. This marks a shift from the usual notion of a home, which primarily served as a shelter. The interior framework for secure smart homes the following components - Strong passwords, two factor authentication (2FA) and Software updates. It is crucial to secure homes with smart technology, as it not only safeguards physical assets of an individual but also provides protection against digital threats. Ultimately, the profound importance of this research lies in its direct impact on human's interaction with secure smart homes having potential to revolutionize the way we interact with and perceive our living spaces, offering a heightened sense of safety, convenience, and peace of mind in an increasingly interconnected world. Securing our homes is important because they are not only our sanctuaries (sacred place) but also a place to relax and feel safe. By taking necessary steps to secure our homes, we can protect ourselves and our families from harm.

Background

In Drew Hendricks' exploration of the history of smart

homes, he delves into the evolution of the concept from imaginative ideas in science fiction to the tangible reality we experience today. The journey begins with the inception of home appliances between 1901 and 1920, marking a significant leap in domestic convenience with the introduction of vacuum cleaners, refrigerators, washing machines, and various other household devices. A noteworthy milestone in the timeline is the ECHO IV, developed in 1966, recognized as the first smart device, helps in controlling home temperature, and managing appliances. The subsequent creation, the Kitchen Computer in 1967, intended to store recipes. The emergence of gerontechnology in 1991 reflects a fusion of gerontology and technology aimed at improving the lives of senior citizens. This era witnessed advancements like Life Alert, addressing the safety and well-being of the elderly.

The late 1990s and early 2000s witnessed the rise of smart homes or home automation, transitioning from a niche concept to a more affordable and accessible reality for consumers. This period saw the introduction of domestic technologies, home networking, and a variety of gadgets.

Importance

Smart homes are important because of the convenience they provide, energy efficiency, enhanced security, remote monitoring of control, increased home value and aging in place.

Aim

The aim of this dissertation is to design and develop an interior framework for secure smart homes and to create an environment where residents can enjoy the benefits of smart technology without compromising their privacy or safety.

Materials and Methods (Methodology)

Smart Homes

A smart home refers to a convenient home setup where appliances and devices can be automatically controlled remotely from anywhere with an internet connection using a mobile or other networked device. Devices in a smart home are interconnected through the internet, allowing the user to control functions such as security access to the home, temperature, lighting, and a home theater remotely. (Hayes, n.d.)

Smart home benefits

Smart homes automate tasks like temperature management, light control, window treatment opening and shutting, and weather-based irrigation, giving you more control over how much energy you consume. Smart homes offer energy-use insights that can make you more environmentally conscious and energy-efficient. Smart homes have the ability to identify locations where you're overusing energy, so you can make savings by making adjustments there.

Literature studies

This section includes the literature studies, which helped me in conducting this research.

Literature Review (Security problems in Smart home) (Coboi *et al.*, 2021) [21].

The widespread adoption of smart home devices necessitates higher awareness and measures to safeguard against security threats. Manufacturers play a crucial role in implementing security features (two factor authentication, end to end encryption) maintaining device updates (on a regular basis). Residents must exercise caution when sharing personal information with smart home apps and adhere to security best practices, such as using strong passwords and keeping devices updated. Overall, the case study highlights the urgency of addressing security concerns in smart homes to ensure the safety and privacy of residents.

Literature Study 1

Sliding Window – Vitrocsa – (“Sliding Window – Mosquito Net | Vitrocsa,” n.d.)

Safety and Security - Vitrocsa meet the requirements and expectations of their clients with regards to safety. Safety measures provided by this product include Alarm directly integrated into the Vitrocsa system, Closed leaf position monitoring, Glass breakage detector and Special burglary-resistant glass.

Threats with regards to alarm identified in this device are – Alarm directly integrated into the Vitrocsa system: An attacker could make changes to the alarm system or disable it altogether.

Possible solutions for this problem identified –Use a two-factor authentication system that requires both a code and a physical key to disarm the alarm.

Solution for the above problem -Vivint smart locks do support two-factor authentication (2FA) for alarms. This means that in addition to entering your password, you will also be required to enter a code from your phone in order to disarm the alarm. (A Guide to Wi-Fi and Your Smart Door Lock, n.d.).

Fig 1: Sliding Window – Vitrocsa

Literature Study 2

Lavna Smart door locks – (“Lavna,” n.d.)

Safety and Security - Up to 100 Fingerprint Unlocking, PIN Unlocking, OTP Unlocking and Manual Key. Security threats with regards to passwords –Weak passwords and Regular software updates.

Solution can be Golen's smart door lock -The Golens Smart Door Lock is a sleek and stylish door lock that features both facial recognition and fingerprint scanning technology. It can store up to 100 fingerprints and 20 faces, making it a great option for families or businesses. The Golens Smart Door Lock also has a built-in doorbell and camera, so you can see who is at your door before you unlock it.

Fig 2: Lavna Smart door locks

Live case studies

This section includes the live studies, which helped me in conducting this research.

Live Study 1 (Door lock – Yale YDR4110 Metal Rim Lock Biometric, PIN Code, Standard, Black)

While doing this case study, I learnt about automatic curtains, motion sensor lights, automated fans, smart door locks and its working. The automation used in this house was Tanti Automatics Pvt. Ltd.

Problems faced in this product – Wrong password attempts leads to the device getting locked and it cannot be opened, even with the right password or fingerprint.

Solution –Lever Yale Fingerprint Lock, Biometric, It is a digital lock with a key hidden within it. The problem I found in this house was regarding a door lock of Yale YDR4110 Metal Rim Lock Biometric, PIN Code and Remote Control, Standard, Black, it would get locked after 5 times a wrong password is entered and this creates a problem, wherein the house owner cannot open the door even with the right password and hence in my finding, I conclude that Lever Yale Fingerprint Lock, Biometric, device can be used as it has a hidden key lock.

Fig 3: Yale lock

Live Study 2 (Lavna Wi-Fi sensor alarm-)

In this case study, the automation used was Synxgen Technologies Pvt. Ltd.

There are few security problems that have been reported for the Lavna Wi-Fi Sensor Alarm for Doors such as False alarms and Battery life. False alarms as in some users have reported that the alarm triggers false alarms, especially when it is first installed. This is usually caused by the sensor being too sensitive or by being placed in a location where it is likely to be triggered by pets or other objects. Battery life as in Some users have also reported that the alarm's battery life is shorter than advertised. This is usually caused by the alarm being frequently triggered by false alarms or by the alarm being used in a cold environment.

Solution – Adium Wirelessly Infrared Detector 110 ° PIR Motion Sensor Pet Immune Smart Home Safety Alarm Security Alarm System pekdi. They are designed to reduce the risk of false alarms by using pet immunity settings. Pet immunity settings: These sensors with pet immunity have adjustable settings that allow you to customize the sensor's sensitivity to pets. This allows you to find the right balance between sensitivity and false alarm immunity.(Adium Wirelessly Infrared Detector 110 ° PIR Motion Sensor Pet Immune Smart Home Safety Alarm Security Alarm System Pekdi, n.d.).

Fig 4: Sensor Alarm for Doors

Table 1: Jist from case studies, the technologies used (2 houses I had worked on for case study)

Feature	Synx Gen Technologies Pvt Ltd	Tanti Automatics Pvt Ltd
Suitability for interior design projects	Good for small to medium-sized projects with limited customization requirements.	Good for all project sizes and with a high degree of customization requirements.
Ease of installation	Easy to install for DIY homeowners or interior designers with basic electrical knowledge.	Requires professional installation by a qualified electrician.
Compatibility with a wide range of devices	Yes, SynxGen is compatible with a wide range of smart home devices from different manufacturers.	Yes, Tanti Automatics is compatible with a wide range of smart home devices from different manufacturers, including the KNX standard.
Pricing of these technologies	5,00,000, was spent for the house in case study 2	13,50,000 was spent on the house in case study 1

Survey's

This research paper adopts a holistic approach by conducting surveys targeting three distinct groups-smart home users, non-smart home users, and interior designers-to comprehensively explore the dimensions of security and privacy in smart home devices. The survey was conducted for a sample of 50, smart home users, 50 non smart home users and 40 interior designers, architects and civil engineers. Through carefully crafted questions, this survey delves into the perceptions, concerns, and practices of each group regarding the integration of these technologies. By comparing responses across these diverse perspectives, this research aims to identify commonalities, disparities, and potential gaps in understanding security and privacy considerations. The findings from this tripartite survey contribute to a nuanced understanding of the multifaceted challenges and opportunities in enhancing security and privacy features within smart home environments, shedding light on the roles of both end-users and design professionals in fostering a more secure and private smart living experience.

Data collection

Mixed method of data collection is employed, it includes quantitative as well as qualitative data. Data is collected based on Privacy Concerns, Security Practices, Attitudes Towards Privacy and Security, Data Sharing Practices, Reasons for not using smart home and Awareness of security and privacy concerns.

Results and Discussion (Smart Homes)

Device study

The literature and live studies I have done has given me insights on the devices of smart homes.

Literature study 1: Result for the problem -Vivint smart locks do support two-factor authentication (2FA) for alarms. This means that in addition to entering your password, you will also be required to enter a code from your phone in order to disarm the alarm.

Fig 5: Vivint smart locks for doors

Literature study 2

Solution can be Golen's smart door lock -The Golens Smart Door Lock is a sleek and stylish door lock that features both facial recognition and fingerprint scanning technology. It can store up to 100 fingerprints and 20 faces, making it a great option for families or businesses. The Golens Smart Door Lock also has a built-in doorbell and camera, so you can see who is at your door before you unlock it.

Fig 6: Golen 's Smart locks

Live study 1

Solution –Lever Yale Fingerprint Lock, Biometric, It is a digital lock with a key hidden within it. The problem I found in this house was regarding a door lock of Yale YDR4110 Metal Rim Lock Biometric, PIN Code and Remote Control, Standard, Black, it would get locked after 5 times a wrong password is entered and this creates a problem, wherein the house owner cannot open the door even with the right password and hence in my finding, I conclude that Lever Yale Fingerprint Lock, Biometric, device can be used as it has a hidden key lock.

Fig 7: Lever Yale Fingerprint Lock, Biometric

Live study 2

Solution – Adium Wirelessly Infrared Detector 110 ° PIR Motion Sensor Pet Immune Smart Home Safety Alarm Security Alarm System pekdi. They are designed to reduce the risk of false alarms by using pet immunity settings. Pet immunity settings: These sensors with pet immunity have adjustable settings that allow you to customize the sensor's sensitivity to pets. This allows you to find the right balance between sensitivity and false alarm immunity. (Adium Wirelessly Infrared Detector 110 ° PIR Motion Sensor Pet Immune Smart Home Safety Alarm Security Alarm System Pekdi, n.d.)

Fig 8: Adium brand sensor

Survey's (Data analysis, Data interpretation)

This research paper adopts a holistic approach by conducting surveys targeting three distinct groups-smart home users, non-smart home users, and interior designers-to comprehensively explore the dimensions of security and privacy in smart home devices. The survey was conducted for a sample of 50, smart home users, 50 non smart home users and 40 interior designers, architects and civil engineers. Through carefully crafted questions, this survey delves into the perceptions, concerns, and practices of each group regarding the integration of these technologies. By comparing responses across these diverse perspectives, this research aims to identify commonalities, disparities, and potential gaps in understanding security and privacy considerations. The findings from this tripartite survey contribute to a nuanced understanding of the multifaceted challenges and opportunities in enhancing security and privacy features within smart home environments, shedding light on the roles of both end-users and design professionals in fostering a more secure and private smart living experience.

Non smart home users

This survey was conducted to understand about the level of awareness non smart home users have about the privacy and security in smart homes. This survey revealed that the majority of the respondents are very concerned about the security and privacy concerns.

Smart homes

This survey revealed that the majority of the respondents are very concerned about the security and privacy concerns.

This survey also depicted that majority of the respondents are concerned about the collection of personal data

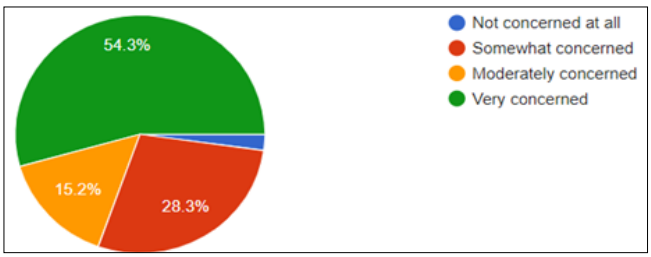

Fig 9: Depicts that majority of non-smart home users are very concerned about the privacy factors in smart homes

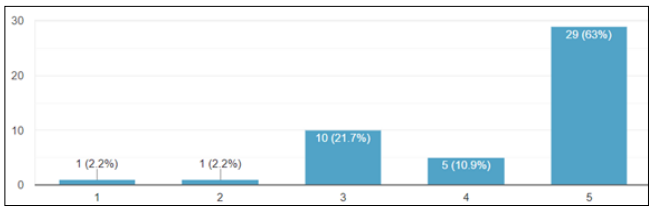

Fig 10: Depicts that majority of the respondents are concerned about privacy factors

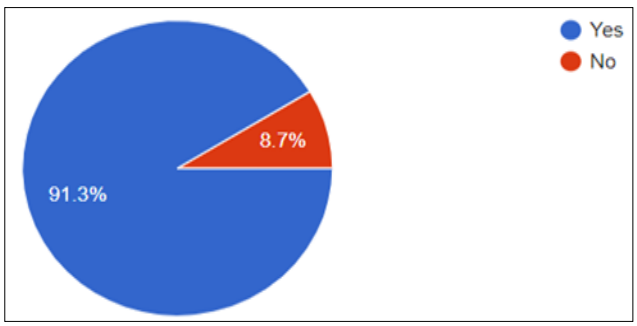

Fig 11: Depicts that majority of the respondents are concerned about collection of personal data

Interior designers, Architect and Civil engineers

This survey was conducted to know how aware interior designers, architects and civil engineers are about the problems in smart homes and to check whether they are educating the clients about the threats in smart home designs or not. They play an important role in educating the clients about benefits in smart home devices as well as privacy and security factors in smart homes.

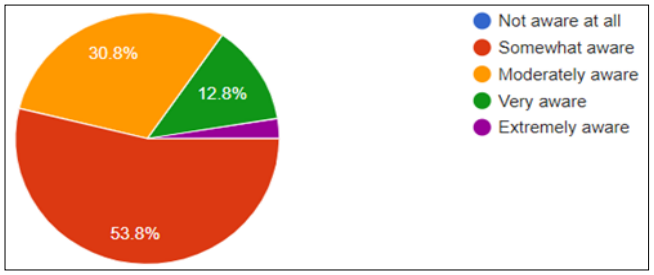

Fig 12: Depicts that these audience often educate their clients about the smart homes threats but not always

This survey also depicted that, these set of audience are not well aware about the security concerns in smart homes.

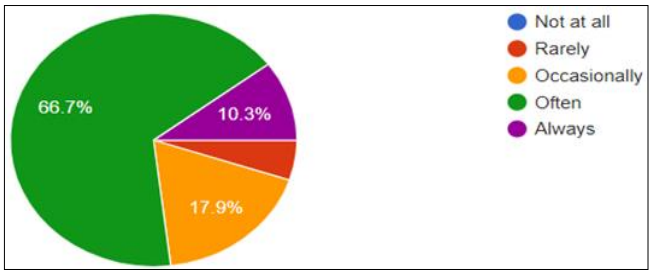

Fig 13: Depicts that these set of audience are not well aware about the security concerns in smart homes

Hypothesis

Declarative hypothesis –Smart homes help in improving lives but introduce new risks therefore, guidelines are needed to identify and mitigate risks while maximizing benefits.

The gap I found in literature study and review was that, there was no research paper which dealt about devices.

Conclusion

Key findings

Finding one's result -Vivint smart locks do support two-factor authentication (2FA) for alarms. This means that in addition to entering your password, you will also be required to enter a code from your phone in order to disarm the alarm. It can be used

near dining areas in luxurious houses maybe which has a swimming pool and good amount of landscape on the other side of the door.

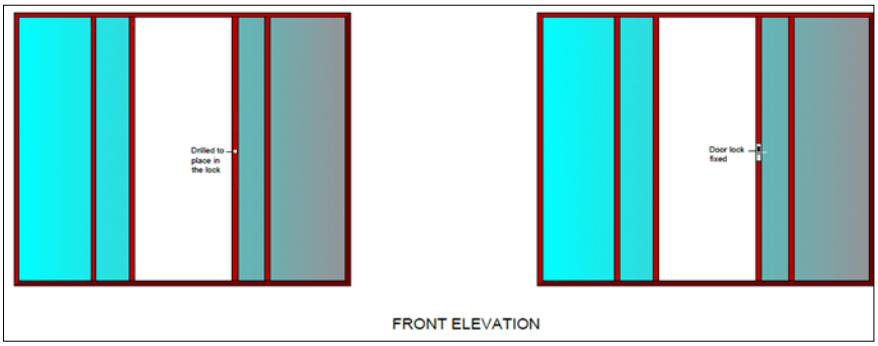

Fig 14: Depicts that side and front elevation of Vivint smart locks

Second finding - Solution can be Golen's smart door lock - The Golens Smart Door Lock is a sleek and stylish door lock that features both facial recognition and fingerprint scanning technology. It can store up to 100 fingerprints and 20 faces, making it a great option for families or businesses. The Golens Smart Door Lock also has a built-in doorbell and camera, so you can see who is at your door before you unlock it. Golen's smart lock can be used near the main entrance of a house, as it provides more amount of safety and convenience, because the person who enters into this house should have their face id registered in this device.

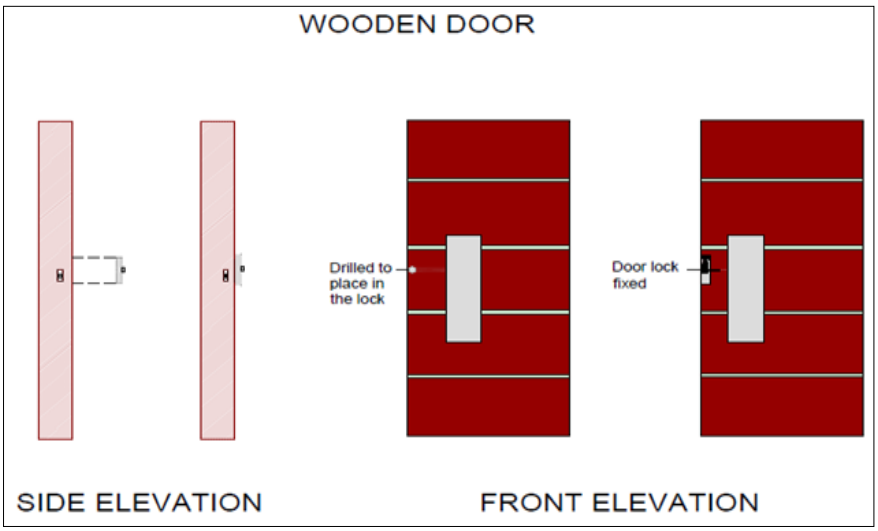

Fig 15: Depicts the working diagram of Golen's smart lock

Third finding - Solution –Lever Yale Fingerprint Lock, Biometric, It is a digital lock with a key hidden within it. The problem I found in this house was regarding a door lock of Yale YDR4110 Metal Rim Lock Biometric, PIN Code and Remote Control, Standard, Black, it would get locked after 5 times a wrong password is entered and this creates a problem, wherein the house owner cannot open the door even with the right password and hence in my finding, I conclude that Lever Yale Fingerprint Lock, Biometric, device can be used as it has a hidden key lock. It can be used for main doors as well as bedroom doors.

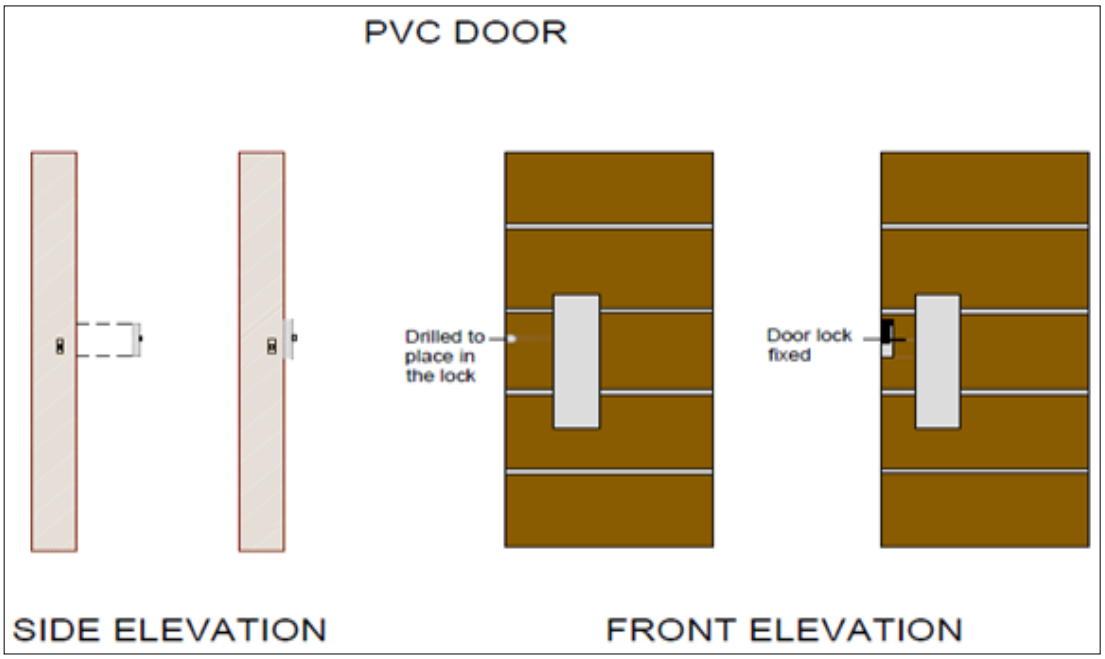

Fig 16: Side and front elevation of Lever Yale Fingerprint Lock, Biometric

Fourth finding - Solution – Adium Wirelessly Infrared Detector 110 ° PIR Motion Sensor Pet Immune Smart Home Safety Alarm Security Alarm System pekdi. They are designed to reduce the risk of false alarms by using pet immunity settings. This allows you to find the right balance between sensitivity and false alarm immunity. It can be installed to the doors, which open its way to balconies, it can also be used for windows in locker rooms, as it enhances safety, security and convenience

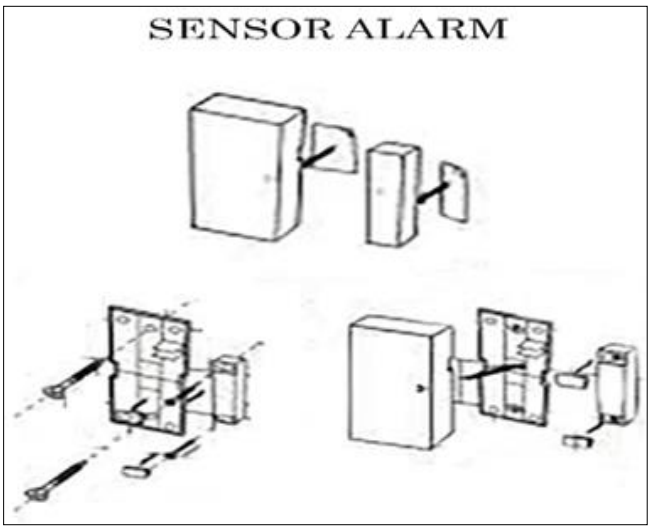

Fig 17: Depicts the working diagram of sensor alarm

Impact

Contribution to knowledge

The benefits smart homes have provided. It is educating the readers about smart home devices with regards to security and privacy concerns. It is contributing to knowledge by identifying problems in few smart home devices and providing solutions, that is suggesting which other device can be used instead.

Practical Impact

Practical impact of this research is that, its providing suggestions to the designers and clients about which smart devices can be used.

Reflection on limitation

Limitations

The dissertation may focus on a limited range of smart home devices or types of devices, leaving out other areas for consideration. The rapid evolution of smart home technologies and the continuous emergence of new devices and security threats may make it challenging to provide a comprehensive and future-proof analysis.

Future research recommendations

Can concentrate on wider range of smart home devices and raise awareness of smart home security risks among consumers.

Compliance with ethical standards

Acknowledgements

I would like to express my sincere gratitude to all those who have contributed to the completion of this dissertation.

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