A Comprehensive Review of Smart Home Automation Systems

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Abstract—*An intelligent house automation system is a technology-driven solution that allows homeowners to control and automate various home devices and systems using a central hub using smartphone, voice command and IoT. The system typically includes equipment such as smart thermostats, smart lighting, smart locks, security systems, and entertainment systems. With the increasing prevalence of IoT, smart homes have become increasingly popular, and automation systems have emerged as a key technology for controlling and managing various home appliances and systems. This note explores an exhaustive detail of the present state of automation systems for smart homes, and aims to identify areas for future research and development along with comfort, energy efficiency, privacy, and accessibility that a smart home automation system offers users can enhance their life as a whole. The current paper also highlights the components of smart home automation system but also put a spotlight on application and challenges associated with it.*

INTRODUCTION

A feasible home design known as a "smart home" allows for the internet-based remote control of gadgets and appliances from any location using a smartphone or other networked device. [1]. Smart homes feature advanced security, remote monitoring, a smart environment, health tracking, and smart home appliances [2].

Wireless home automation system technologies include GSM, Bluetooth, ZigBee, wi-fi based, etc. [3]. Voice activated assistants [4], sensors [5], programmable controllers [6] and wireless home automation system [3] together all makes the automation system for smart homes. Energy management, security management, entertainment management, cooling management, and other automation system applications are used in smart homes [2]. Interoperability, which will allow for simple integration with the current internet of various smart gadgets is also a challenge [7].
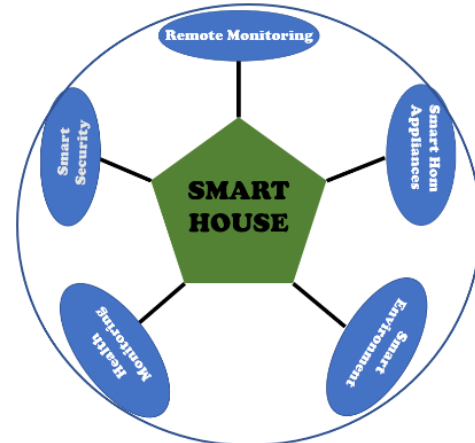

Figure 1: Smart House depicting its features [2].

A significant obstacle to home automation is infringements of smart home applications, such as unlawful info collecting, which may reduce reassure perspectives and the willingness to utilize it [8].

2. COMPONENTS OF AUTOMATION SYSTEMS FOR SMART HOMES.

2.1 Wireless Technology

2.1.1 GSM Based Automation Systems

Global system for mobile communications is the full form of GSM and it is long ranged communication [12] but it is slowest [13]. A GSM Module can be employed in achieving house automation systems which in turn is low-cost proposal.[9] It also requires microcontroller and relays. GSM Technology is also used in [1] for sending SMS and granting remote access. [10] shows GSM technology can be used for security and safety of our houses. For achieving smart home security [11] also uses GSM based approach.

2.1.2 Bluetooth

In recent years it is possible to achieve low-cost Bluetooth driven smart home automation systems [3]. It provides better precision and accuracy than GSM and equivalent to wi-fi but it dominates in terms of speed [13]. It is short ranged communication [14]. It is cost effective and energy efficient [15].

2.1.3 ZiII Meaning of Motherhood

The current study has certain limitations that need to be considered for future research The limitations of the study was that this study considered only few factors of job stress like role ambiguity, job satisfaction and job performance This study adopts cross sectional survey design. Future research can be done with a large sample size to better understand the impact of job stress and role ambiguity on job satisfaction and job performance.

Limitations and Future research scope gbee

IEEE 802.15.4 is wireless networking standard of ZigBee that supports low power and low data rates and is primarily used for two-way communication between sensors and control systems [16]. Setup and running costs are minimal [13].

2.1.4 Wi-Fi

Wireless Fidelity, enables equipment and devices to connect to the internet [17]. Wi-Fi enabled automation systems also can be operated remotely and better encryption (security) capabilities [18].

2.1.5 IOT

Kevin Ashton gives the phrase "Internet of things" in the first presentation in 1998[19].

The IOT based control system and monitoring for home appliances was created in [20] and made use of mini web server, a smart phone, software apps, and controlling hardware [20].

Due to its many smart feature and capabilities, IoT and Wi-Fi based smart home systems are treated as the most versatile and user-friendly solutions [13].

2.2 Sensors

2.2.1 Temperature sensor

LM 35 is very accurate integrated circuit temperature sensor and its output potential difference is linearly correlated to the temperature in degree Celsius [21]. LM35 is widely used in automation systems for temperature detection [1].

2.2.2 Humidity Sensor

The quantity of moisture or water content in the air is referred to as humidity [22]. Four-pin DHT11 is a well-known Humidity sensor [22].

2.2.3 Gas Sensor

A common sensor for identifying a number of gases, such as propane, methane, and smoke, is the MQ2 gas sensor [23]. It is a low-cost sensor with broad gas sensitivity that is frequently utilized in the detection of gas leaks [23]. Arduino UNO can be attached to it and this is simple on using [23].

2.2.4 Light Sensor

Photoresistors, sometimes referred to as Light-Dependent Resistors, are the most popular form of light sensor utilized in a light sensor circuit (LDR) [24]. Photoresistors evaluate the relative light levels throughout the day and determine whether a light is on or off [24].

2.2.5 Motion Sensor

Motion sensor and human body detection sensor is achieved by Passive infrared sensor [25].

2.2.6 Contact Sensor

For security purposes of door and windows, magnetic contact sensors are extensively used in [25],[26].

2.2.7 Occupancy Sensor

[27] proposes usage of occupancy sensor to save energy at homes. HVAC system will be turn off when there is no one in house for saving energy [27].

2.3 Programmable Controllers for Automation system

Widely used controllers for smart home automation system are Arduino, Raspberry pi and Node MCU [33].

2.3.1 Arduino

ATmega328P microcontroller is embedded on Arduino UNO [31]. It is an open-source platform designed for building electronics projects. This board contains reset button, an ICSP header, a USB connection, a power jack, a quartz crystal and has analog and digital pins [31]. The board can be programmed using the Arduino programming language, which is based on C and C++, and IDE [31]. The Arduino Uno is exhaustively used in various domains, such as robotics, automation, IoT, and many others.

[10],[21],[23]and [28] uses basic Arduino uno for their work.

ATmega2560 microcontroller is embedded on Arduino mega [1]. It is one of the most powerful boards in the Arduino family and is designed to provide users with more input/output (I/O) pins, more memory, and more processing power than the standard Arduino boards. The Arduino Mega board has digital output and input pins, analog inputs, and four serial ports. It also features a quartz crystal, a USB connection for programming and power, an ICSP header, and a reset button [30]. The board is compatible with most shields designed for these boards and may be programmed using the Integrated Development Environment [1].

[1]and [29] used Arduino mega for research work.

2.3.2 Raspberry Pi

A general-purpose computer is called raspberry pi that can be used for many types of tasks, including as a controller for various smart devices and systems. It is power-efficient multi-core CPU that is built as a System-On-Chip, weighs 50g,

having power rating of 5V, 700mA [32]. There are three types of this board: A, B, and B+ [32].

2.3.3 Node MCU

It is a microcontroller built on the Arduino platform that also includes an ESP8266 Wi-Fi chipset [34]. This microcontroller has a storage capacity of 4 MB and 128 kB of memory [33]. It is often employed for a single Internet of Things application or to do away with the necessity for a central processing unit. The Node MCU has a substantial economic advantage over the competition since it can connect to the world-wide network through Wi-fi without the use of any extra equipment or modules, giving it this advantage over the competition [33].

2.4 Voice activated assistants

Software agents known as speech assistants can understand spoken language and reply with unrealistic voices [35]. The most well-known examples are Amazon's Alexa, Microsoft's Cortana, Apple's Siri and google assistant, they are all made into smartphones or home speakers [35]. These devices can answer basic questions of information and arithmetic, most importantly control IOT devices [35]. These Devices even can read and send text messages, emails, etc. and make phone calls [35]. Edu et al reviewed these devices on basis of security and privacy issues [36].

3. COMFORT OF SMART HOME AUTOMATION SYSTEMS

There are several forms of comfort requirements for people in their smart houses such as sintering pleasure related to temperature and humidity, luminous pleasure related to lights and colours and pleasant pleasure related to air quality [33]. By applying concept of machine learning, IOT and artificial intelligence, in smart home we can be smoothly visualized and observed comfort[37].
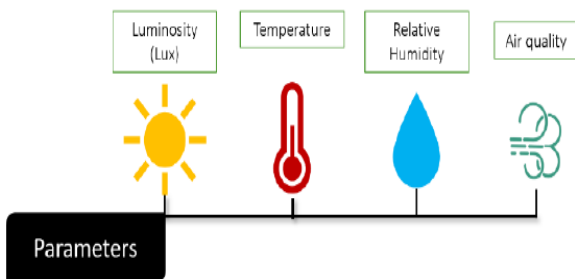

Figure 2: Figure depicting parameters of comfort in smart home [33].

4. ENERGY EFFICIENCY IN SMART HOME AUTOMATION SYSTEM

Energy-efficient smart homes refer to homes that use technology to reduce energy expenditure and improve energy performance while providing comfort and convenience to its occupants [2]. House energy management system also plays an critical contribution in saving energy at intelligent house [44].
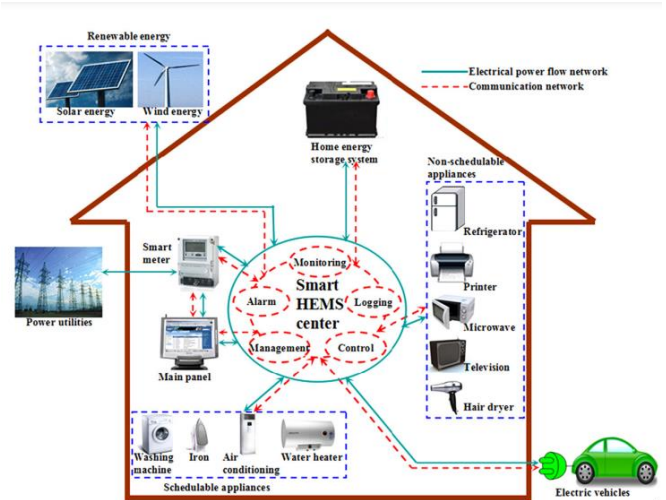

Figure 3: Architecture of HEMS [44].

Table 1: Research paper published regarding Energy Efficient Smart Homes with their key findings

Research Paper	Key Findings
Smart home automation system for energy efficient housing [38].	Low-cost energy efficient system was made using plc, CPU, wireless sensor network.
Smart Energy Efficient Home Automation System Using IoT [39].	With help of IOT, energy efficient smart home automation is achieved
Low-Cost and energy-efficient smart home security and automation [40].	Using Raspberry pi as main controller for achievement of energy efficient smart home automation
Application of Scheduling Techniques for Load-Shifting in Smart Homes with Renewable-Energy-Sources Integration [41].	Using load shifting algorithm in intelligent houses for conserving energy.

5. PRIVACY ASPECT IN SMART HOME AUTOMATION SYSTEM

Privacy is the concern that people use for maintaining their own private space, independent from intrusion by other users and community [42]. Data is also gathered by cameras, motion detectors, and light sensors. The majority of this data include private and/or delicate piece of information, including addresses, positions, images, and network access details [42]. There are several cases discussed in [42] of data collection.

6. ACCESSIBILITY TO SMART HOME AUTOMATION SYSTEM

Smart Home must be accessible to all family members including person with disability. Person with visual disabilities can also access smart home with the use of head tracking devices [43]. Head tracking devices are gesture recognition devices and with help of facial movements we can navigate [43].

7. CHALLENGES ASSOCIATED WITH SMART HOME AUTOMATION SYSTEM

7.1 Several new smart items or gadgets are connecting to the network on their own. In order to handle problems like addressing, information management, and service management, IoT should be able to support both small- and large-scale contexts [19].

7.2 Interoperability

In the IOT, a huge number of linked smart items each have their own information gathering, processing, and communication capabilities. There should be a common communication standard for the smart objects of all sorts to cooperate and communicate with one another [7].

7.3 Providing security and privacy in an internet-based network made up of smart things is a big issue. In the IOT, users occasionally stop other users from accessing certain information at specific times, or they block communications or transactions to safeguard sensitive information from rivals. So, managing this scenario is really difficult [19].

8. FUTURE OF SMART HOME AUTOMATION SYSTEMS

Some of advancements that we can see in future in smart home automation system are as below: -

8.1.1 Increased integration

As more smart devices become available, we can expect to see greater integration between different systems in the home. For example, a smart thermostat may work in tandem with a smart window system to adjust temperature and natural light for optimal energy efficiency [47].

8.1.2 Enhanced AI capabilities

With advancements in artificial intelligence, smart home automation systems will be able to learn and adapt to users' habits and preferences, making them even more convenient and efficient. For example, a smart home may be able to anticipate a user's arrival home and have the lights and temperature set to their preferred settings.

8.1.3 Greater control via wearables

Smartwatches and other wearables may become more integrated into intelligent house automation systems, allowing users to control their house from anywhere with just a few taps on their wrist.

8.1.4 Increased emphasis on sustainability

As climate change becomes a greater concern, smart home automation systems may become even more focused on sustainability and energy efficiency. For example, solar panels and energy storage systems may become more prevalent in smart homes [46].

8.1.5 Greater focus on health and wellness

Smart homes may become even more focused on improving users' health and wellness, with features such as air purifiers and smart lighting that adjust based on the time of day and users' activity levels [45].

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