Smart Home Automation System Using Advanced Embedded System Platforms with AI and IoT

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Abstract: The rapid advancement of electrical, computer, and information technologies has made it possible to build and implement a variety of so-called embedded systems that are employed for a wide range of needs and goals, as well as for numerous real-world applications. Such systems are created and put into use in order to be as closely as possible customized to specific applications and to effectively carry out necessary functions. Additionally, such systems should be as easy to use, as compact as possible, as inexpensive as possible, and as energy-efficient as possible. Now a day, automation term is very common in various sectors like industry, garden, restaurant, hospitals and home and so on. Using sensors and Advanced Embedded System Platforms (AESPs) we can develop Smart Home Automation Systems (SHAS), Such types of systems included Internet of things (IoT), System on Chip (SoC) and other communications standards on a single board and can be supported with Artificial Intelligence (AI). Hence, in this paper, we present a short review of Smart Home Automation Systems (SHAS) using Advanced Embedded System Platforms (AESPs) with AI and IoT support. Depending upon the application, implementation of AESP along with AI reduces the cost of SHAS and enhances the system reliability, safety, compactness, energy management and user-friendliness.

Keywords: Internet of Things, Artificial Intelligence, Advanced Embedded System Platforms, Home Automation, System on Chip.

1. Introduction:

Embedded systems are electronic devices that have very tight hardware and software compatibility and are made to carry out a certain set of tasks. Such embedded systems can be developed, designed, and implemented using a variety of hardware and software options, as well as hardware and software platforms. The majority of those are platforms and solutions based on microprocessors. Embedded systems serve a specific purpose and are totally contained by the object they govern. One or more predetermined tasks are carried out by such a system, typically with highly exact specifications [1]. The development of microprocessors and microcontrollers gave rise to the embedded systems sector. Today, a variety of embedded system platforms, including Arduino, Raspberry Pi, and Beagle Bone Black, are commercially available.

Although Internet of Things (IoT) is a very broad term, it is define as a network of intelligent devices which are equipped with sensors, networks and various processing systems which communicate with each other with or without human interventions depending upon need. Artificial Intelligence (AI) is nothing but replication of human intelligence with help of machines or computer with tremendous capabilities. Expert systems with intelligent algorithms, natural language processing units, speech recognition units, machine vision are some of the important blocks of the AI system which overcome the limit and limitations of human being.

These embedded platforms give Internet of Things (IoT) and System on Chip (SoC) devices additional freedom when integrating communication protocols with actual hardware and efficiency increases several folds along with AI. Additionally, offer In System Programming (ISP) for system hardware and software debugging tools. By employing these platforms, new possibilities are established for the development of various developments [2].

The Internet of Things (IoT) with Wireless Sensor Networks (WSN) is one of the most important technologies of the twenty-first century. An IoT device that integrates sensing, computing and communications. During the 1990s, wireless sensor networks were first employed for environmental, engineering, agriculture, and ecology applications. Smart, real-time, compact, multipurpose, low-cost embedded devices are used in the developing field of IoT with WSNs for a variety of uses and do not rely on any pre-existing infrastructure such as home automation. The IoT is regarded as the intelligent connection of ubiquitous objects such as smart phones, Internet TVs, detectors, and actuators to the internet, providing new forms of communication between things and people, as well as amongst things themselves. The Internet of Things (IoT) can be utilised for a variety of purpose [3, 4].

The luxury and standard of living are improved by Smart Home Automation Systems (SHAS), which have been very prominent in recent years. Currently, a smartphone and Advanced Embedded System Platforms (AESPs) make up the majority of Smart Home Automation Systems (SHAS). Utilizing different communication channels, a smart phone application is utilised to tablet and operate the household appliances. Currently, the majority of SHAS are employed to make life easier for the elderly and disabled while also lowering the amount of human labour required for the creation of goods and services. One controller can be used to design and develop a SHAS [5]. This controller can operate and monitor a variety of interconnected appliances, including electricity plugs, bulbs, humidity and temperature sensors, burglary, gas, and smoke alarms, as well as safety and rescue systems.

The ability to quickly control and monitor a SHAS from a variety of devices, including a smartphone, tablet, desktop, and laptop, is one of its major advantages. We use smartphones to remotely operate and keep an eye on household appliances all over the world due to the rapid development of wireless networks [6, 7].

2. Literature survey:

The purpose of introducing a smart home system is not new; it has been around since the American Association of Construction Companies first used the term "smart house" in 1984. The use of various technologies will benefit the aged and physically handicapped as well as modern society's comfort level and AI supports for enhancement of the system reliability, compactness and user-friendliness. Scientists across the board are attempting to integrate smartphones with processor-based home automation systems. Home automation integrates simple binary devices the most frequently in the real world. This encompasses both "on and off" equipment like lights, plugs, and electronic appliances as well as "two state" devices like security sensors that can only be in the open or closed position. The early automation technologies were relatively ineffective because they operated just one or two devices and could only be employed for a few specific tasks [7-9]. On the bases of study of review papers based on Smart Home Automation Systems (SHAS) following advanced platforms of embedded systems are discussed.

Satpathy, L., et al. [10] presents a smarter housing concept that is more suited. "A home is referred to as a smart home if it is smart enough to let the residents live effectively and securely with the aid of technology," says Sampath. A network made up of all the mechanical and digital components of a smart home can interact with one another and the user to enhance the current environment. The term "smart home" refers to a ubiquitous computing application that can offer context-aware automated to users, such as ambient intelligence, remotely control, or home automation. This definition takes into account the current developments in research on smart homes.

Saeed, U., et al. [11] presents a system for home automation occurs mainly around Short Message Service (SMS). An Android application built for this system is designed to operate on the user's smartphone. Authorized users can access the app by entering their username and password, and they can then remotely access some of the features and do other operations from the list of user actions that are offered. The user will receive the necessary notification from the programme.

Hossain, M. et al. [12] utilizing an AVR (ATmega8) microcontroller, a modern home automation system was developed. With the help of a dual op amp and an Infrared (IR) sensor circuit, the circuit board can detect presences and produce analogue output that is sent to the microcontroller. The Analog to Digital Converter (ADC) of the microcontroller has transformed the analogue data into digital form. Lighting and fans are thus turned on by the microcontroller. The pulse width of the fans has been developed using software in a variety of ways to change their speed. The DC motor that serves as the fan's representation has been driven by a motor driver Integrated Circuit (IC). When there are more people there, the fan runs faster due to the microcontroller.

Aziz, W. et al. [13] developed a Smart Home Automation Systems (SHAS) that focused on helping handicapped and elderly people to perform their chores routine such as turn on or turn off fan and light, so that it can be done wirelessly by using handheld devices such as Smartphone. This system will be based on Raspberry Pi, and is designed to be an affordable and reliable home automation system yet, easy to setup and use. According user needs, that can be done using the scheduling function for automatic operation of home appliances. Python Tkinter which is standard Python interface and binding to the Tk GUI toolkit, is used to develop the Graphical User Interface (GUI) after it has been designed. It serves as a conduit between the user and the Micro Controller Unit (MCU) for the control and status monitoring of the home appliances linked to the Indication of Interest (IOI) unit as well as for webcam systems and security screening. This prototype system features a webcam as its only input, two outputs a light and a fan and two separate inputs. The user has the option of turning on or off the light, and he or she can choose between speed 1 (the lowest), speed 2 (the medium), or speed 3 (the highest) for the fan.

Jamil, M., et al. (14) developed a Raspberry Pi-based Hospital Administration Software (HAS). The input/output interface unit and the MCU, which comprises the Raspberry Pi, are the two essential components of this system. The credit card-sized Raspberry Pi features all the standard ports found on a typical PC or laptop, including video and audio outs, High Definition Multimedia Interface (HDMI) ports for high definition displays, two USB host ports, and an RJ-45 Local Area Network (LAN) interface. It also has an ARM (Advanced RISC Machine) microprocessor. To give the MCU wireless connectivity, a Wi-Fi dongle is connected to the USB port. The Raspberry Pi differs from a typical computer in that it has a General Purpose Input/Output (GPIO) port, which enables simple connecting with external electronics to facilitate home automation.

Bababe Adam, et al. [15] developed Intelligent Home Automation System using Lora. LoRa is a brand-new, power long-range wireless protocol that has been created to allow sensors and other power devices to communicate at modest data rates across great distances. Millions of devices can be safely connected to the cloud using LoRa which is a Long Range and Low Power wireless platform and the related LoRaWAN network protocol which is mainly use for Wide Area Network (WAN) through secure local, regional, national, or international networks. The Internet of Things' primary enabler, LoRa, is swiftly rising to importance.

3. History of home automation systems:

Since the 1970s, there has been speculation of home automation. However, as technology has progressed and smart services have become more accessible, people's expectations for how well a conventional house can be transformed into a smart home have modified significantly over time. These preconceptions have affected how people view home automation systems as well as what a home should be able to do and how services should be made available and accessed at home [16]. As internet technology progresses quickly and smart homes abruptly became an option that was more feasible, home automation started to gain appeal in the late 1990s and early 2000s. As household appliances and computers increasingly merged, the concept of domestic technology became a major topic.

3.1 Microprocessor based home automation systems:

Microprocessors are now found in a shockingly wide variety of chips that power everything from cell phones to supercomputers. On a single Integrated Circuit (IC), a microprocessor performs the duties of a Central Processing Unit (CPU). The heart of all computer systems and numerous home and electronic gadgets is the microprocessor, sometimes referred to as the CPU. Microprocessor-based products, like microwaves and cell phones, have become so ingrained in our daily lives that we find it impossible to fathom existence without them. PCs use general-purpose microprocessors to display multimedia, compute, formatting text, and communicate. Gadgets, cars, cell phones, and industrial operations control are just a few of the things that the embedded microprocessors can digitally operate.

Shoewu, O., et al. [17] developed based automatic gate using a microprocessor Z80. The difficulties with gate functioning have prompted a thorough search for alternatives. Due to the incorporation of a microprocessor, the automatic gate with a processor provides everything required to put an end to these difficulties. A developed system keeps an eye on the entrance and exit gates. Any incoming car is detected by the automatic gate. It automatically opens, waits for a predetermined amount of time, and then closes. The system counts, logs, and shows the number of vehicles as immediately as the gate closes. By counting the number of vehicles those have entered the area and calculating the maximum amount of available space in the parking area, the device also works as a vehicle parking control unit. When the system detects that there is no more room available, it sounds an alert for a certain amount of time and locks the entrance gate until a different vehicle exits through the exit gate.

3.2 Microcontroller based home automation systems:

Kaur, I., et al. [18] developed home automation system with security using 89S52 microcontroller. Author used Sensors, Stepper motor, LDR, LED, LCD display, ADC, Relays and 89S52. 89S52 is the heart of the developed circuit in this work. Authors also tried to show automatic control of a house as a result of which power is saved to some extent. The some advantageous of the developed system are authors made sure the locking mechanism in this system was secure. Although the lock would not be visible externally, the built-in locking system provides security. The lights won't turn on if it's a sunny day, but they will turn on automatically when it becomes dark. When the temperature rises, the fan will automatically turn on. It will continue in the off state if not. The inner section and outside sections of buildings both use this light-saving technique. The bulbs will automatically turn on if no one is home or if someone is seated in the room and it is dark outside; they will turn off when it is light outside. Consequently, power is conserved. This component sets off an alert or other signal when it detects any fire or fire-related smoke.

The series of 8051 microcontroller have been implemented tremendously in the field of home automation by using different communication standards like Dual Tone Multi Frequency (DTMF) [8], Bluetooth [19], Global System for Mobile (GSM) communication [20], Global Positioning System (GPS) [21], Zigbee [22], Radio frequency (RF) Module based [23] and so many other. These wireless standards have lot of advantages as well as drawbacks in SHAS.

3.3 Advanced Embedded system platform based home automation systems:

Different Advanced Embedded System Platforms (AESPs) including Arduino, Raspberry Pi, LoRa board, and Beagle Bone Black, are now available in the market. These platforms have important features like IoT, SoC, WiFi Module, operating system, and real-world devices additional options when integrating communication protocols. In order to use these platforms to create new chances and challenges for the development of various future advanced embedded system applications, also give Internet Service Provider (ISP) on system hardware and software debugging tools. Figure 1 reveals the advancements in embedded platforms.
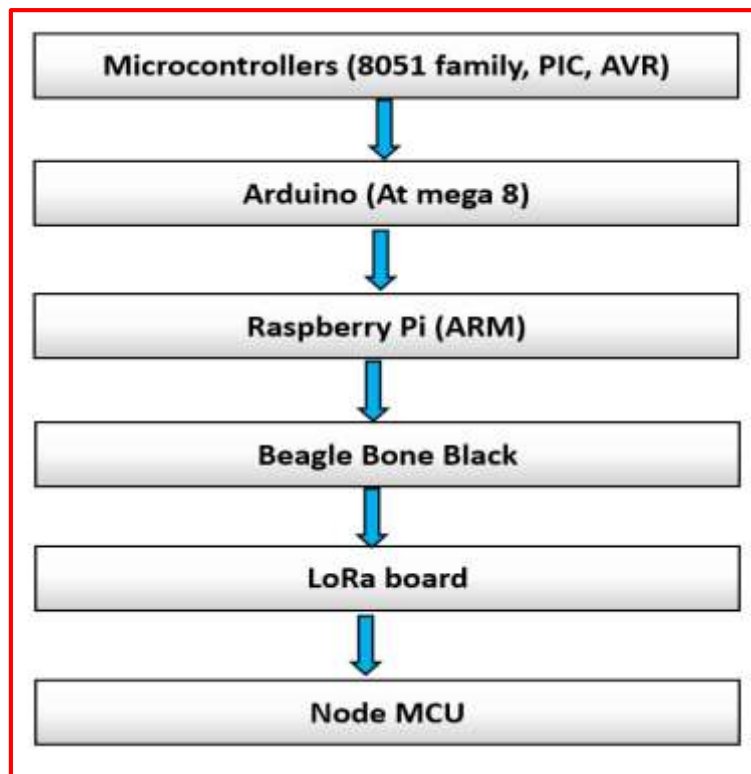
Figure 1: Advancements in embedded platforms

The major components as well as devices required in Smart Home Automation Systems (SHAS) is shown in Figure 2.
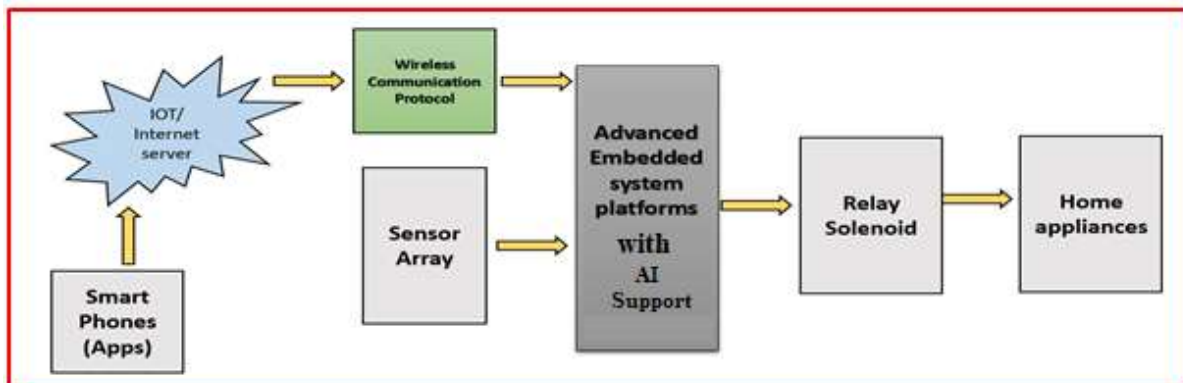

Figure 2: Generalize block diagram of Smart Home Automation Systems (SHAS)

4. Role of sensors in smart home automation systems:

We are encircled by intelligent machines that can make decisions under their own nowadays due to digital explosion, often with little to no human input. Employing a real-time home automation system that keeps track of factors like power usage and person presence would also make our house smart. Supervision of household equipment, lights, surveillance, and other devices may be unified as part of home automation.

Smart sensors are devices which gather data from their immediate environment. Once they recognise certain input, they utilise built-in computer resources to carry out predefined duties. The data is then processed by the smart sensors before being transmitted. In a wide range of situations, including combat investigation and surveillance, smart sensors are used. Automation is impossible without sensors. They instruct how and when to operate connected devices. Figure 3 shows various types of sensors are used in automation.
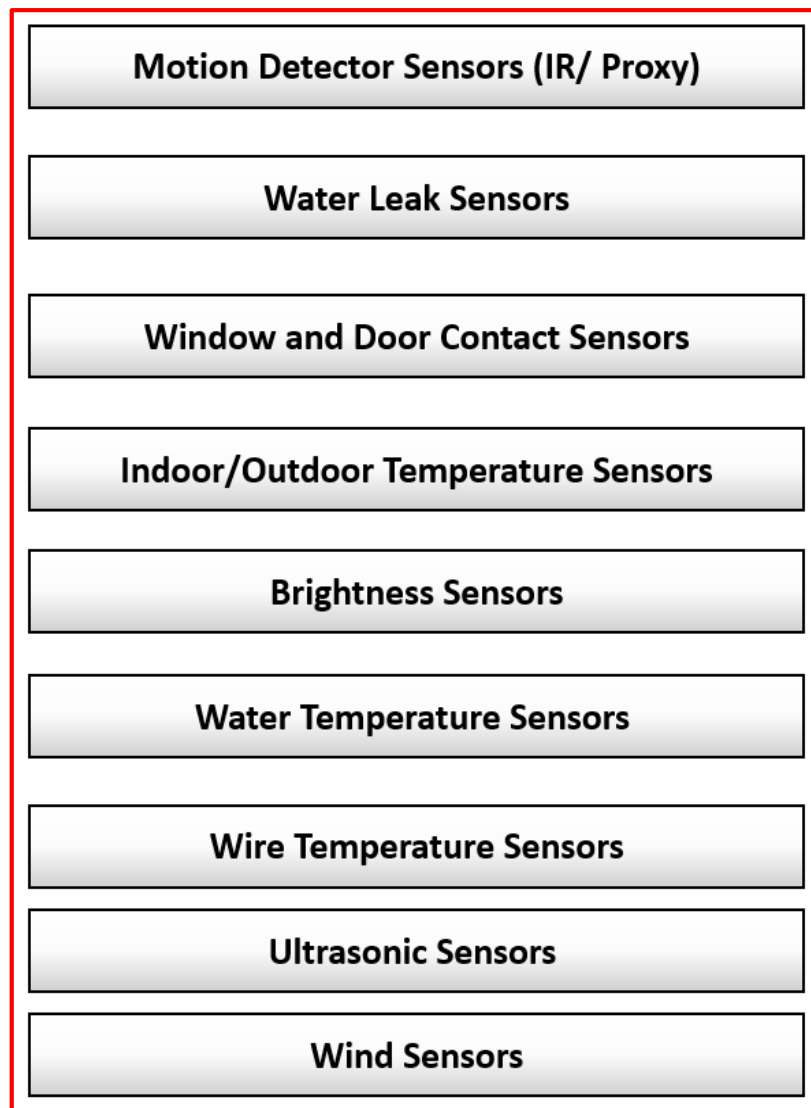
| Motion Detector Sensors (IR/ Proxy) |
| Water Leak Sensors |
| Window and Door Contact Sensors |
| Indoor/Outdoor Temperature Sensors |
| Brightness Sensors |
| Water Temperature Sensors |
| Wire Temperature Sensors |
| Ultrasonic Sensors |
| Wind Sensors |

Figure 3: Types of Sensors used in Smart Home Automation Systems (SHAS)

Conclusion:

In this short review paper, the concept of the Smart Home Automation Systems (SHAS) using Advanced Embedded System Platforms (AESPs) with Artificial Intelligence (AI) and Internet of Things (IoT) support have been presented. AI and IoT enhance the system reliability, safety, compactness and user-friendliness of the systems and useful in various sectors like industry, garden, restaurant, hospitals and home and so on. Smart sensors and communication standards available in the market that allow an intelligent energy management, security and surveillance to the homes. Also focus the types of sensors as well as various advanced embedded system platforms in the current research paper.

Acknowledgment:

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