Implementation of Arduino Based IOT Home Automation Systems in Sri Lanka

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Abstract— *The deployment of microcontroller-based IoT home automation systems in Sri Lanka are examined in this review paper, with an emphasis on the subtopics of home automation, irrigation automation, waste management and healthcare automation. By offering a thorough review of IoT and home automation systems, this research intends to close a gap in the existing literature. It is a helpful tool for researchers looking to gain a thorough understanding of the subject and provides information on the significance of the difficulties facing these systems. A thorough evaluation of the literature on Arduino-based IoT home automation systems is undertaken, spanning system design, communication protocols, sensor integration, energy efficiency, user interface and security issues. The paper investigates the uses of Arduino-based IoT solutions in the context of home automation and includes case studies and implementation examples. The studied literature is compared to evaluate the effectiveness and efficiency of Arduino-based IoT solutions across the subtopics. In addition, the evaluation reveals gaps and issues in the field. The paper finishes with recommendations for future research directions and emerging trends based on the review's results. It focuses on developments in home automation technology, prospective applications in Sri Lanka, research opportunities and difficulties. Overall, this review is an excellent resource for researchers and practitioners interested in deploying Arduino-based IoT home automation systems in Sri Lanka, providing insights into the present status of the field and guiding future research.*

Keywords— **Arduino, IoT , Home Automation**

I. INTRODUCTION

The Internet of Things (IoT) has developed as a disruptive technology in recent years, connecting common devices to the internet and allowing for seamless communication and data sharing. One of the primary areas where IoT has made a difference is home automation, which has the potential to improve convenience, energy efficiency, and overall quality of life in residential settings.

Sri Lanka, a developing country with a growing interest in smart technology adoption, provides a unique setting for investigating the application of Arduino-based IoT home automation systems. As technology becomes more accessible and affordable, there is an increasing need to study how IoT might be used to address specific difficulties confronting Sri Lankan households.

The importance of adopting an Arduino as the microcontroller in this study resides in its affordability, adaptability, and wide-ranging support from the community. Comparatively inexpensive to other microcontrollers, Arduino boards are available for study and practical use. Wi-Fi, Bluetooth, and Ethernet are just a few of the numerous connection choices that Arduino provides, enabling easy integration with a variety of smart home systems and appliances. Additionally, the Arduino platform has a sizable developer and enthusiast community that actively shares knowledge, code, and projects. As a result, researchers have access to priceless resources and may quickly prototype and execute new ideas. Because of its accessibility, adaptability, and community support, Arduino is the perfect platform for investigating and creating cutting-edge home automation solutions.

The goal of this comparative study is to bridge the gap between existing research and the practical deployment of home automation systems in Sri Lanka. This paper assist informed decision-making and contribute to the development of efficient and effective IoT-based home automation systems targeted to the needs of Sri Lankan families by identifying best practices, flagging limitations, and giving recommendations. Because of its price, user-friendliness, flexibility, and availability to a supportive online community, Arduino-based IoT approaches are substantially better for developing countries like Sri Lanka than other alternatives.

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While there is a substantial body of study on IoT home automation systems around the world, there is a dearth of comprehensive studies concentrating on the specific application of these systems in Sri Lanka. With a specific focus on Sri Lanka, this study aims to address the distinctive socioeconomic and environmental characteristics of that nation. It offers analyses and suggestions that are targeted to the requirements of different stakeholders, including policymakers, businesses, and the public. To ensure that their difficulties are handled, key topics including efficient resource management, sustainability, and healthcare accessibility are highlighted.

The aim of the research is to learn how Arduino-based IoT devices might be used to address these difficulties and improve the overall quality of life for Sri Lankans by investigating the subtopics of home automation, irrigation automation, waste management, and health care automation.

The purpose of this paper is to conduct a literature review exploring the deployment of Microcontroller-based IoT home automation systems in Sri Lanka, and to provide main findings, discussion, and further research directions on this domain. Sixty-four papers were found in the scientific literature. All papers demonstrated different divisions of home automation systems. None of the papers reviewed presented a suitable cost-effective solution for an average Sri Lankan household in whole. This represents an important area of opportunity for research with relevance to industry. The literature review findings call for further research and implementation advances in Sri Lankan home automation industry.

II. OVERVIEW OF HOME AUTOMATION SYSTEMS

The Internet of Things (IoT) is a network of interconnected physical devices, automobiles, appliances, and other items that are equipped with sensors, software, and networking capabilities to collect and exchange data over the internet. It is a concept that entails integrating multiple smart gadgets and systems in order to create an intelligent and automated environment.

Home automation is the use of IoT technology in residential settings to automate and control various areas of the home. It entails integrating smart devices, sensors, and connection technologies to provide remote monitoring and management of home appliances, security systems, lighting, heating and cooling systems, entertainment systems, and other systems. The Internet of Things (IoT) idea in home automation attempts to create a connected and smart home environment in which various devices and systems may interact and collaborate with one another as well as with the homeowners or inhabitants. Home automation systems enable homeowners to remotely manage and control their homes, monitor energy usage, improve security, maximize comfort, and create personalized experiences by leveraging sensors, actuators, and communication technologies. (Wadhwani, 2018)

The use of IoT technology in home automation systems enables the centralized management and control of various devices via a single interface, which is frequently a smartphone app or a voice-activated assistant. Homeowners may establish personalized schedules, automate routine tasks, receive alerts and messages, and remotely access and control their home devices and systems thanks to this connectivity and automation.

Implementing an IOT-based home automation system can provide numerous benefits. IoT home automation systems provide unprecedented ease by allowing homeowners to remotely control and manage numerous gadgets and systems. Users can automate normal processes, change settings, and get notifications or alerts via a centralized interface. This level of control and flexibility improves comfort and makes daily activities easier. They also provide energy optimization by monitoring and controlling energy-consuming devices in real time. Homeowners can program automated operations like altering heating and cooling settings based on occupancy or regulating lighting based on natural light conditions. This results in energy savings and lower utility bills. Home automation solutions that incorporate IoT technology provide increased security features. Homeowners may monitor and control security cameras, door locks, and alarm systems remotely, improving home security and providing peace of mind. Furthermore, IoT devices can identify odd activity or breaches and immediately notify homeowners or security providers. Also, consumers can make personalized settings and preferences for various devices and systems. This includes customizing lighting scenarios, altering temperature and humidity levels, and configuring preferred entertainment configurations. Customization options provide for a more personalized living experience based on personal preferences. Furthermore, homeowners can access and monitor their homes remotely from anywhere using smartphones or other internet-connected devices. This tool is especially useful when homeowners are traveling or away from home because it allows them to check on security, modify settings, or receive real-time updates.

Numerous challenges are there in the process of implementing smart home automation systems. Different manufacturers' IoT devices and systems may employ different communication protocols and standards, resulting in interoperability difficulties. It can be difficult to ensure seamless integration and interoperability among devices from different vendors, which necessitates the use of standardized protocols and attempts to overcome communication gaps. Concerns concerning data privacy and security are raised by IoT home automation devices. With lots of connected devices collecting and exchanging data, the potential of unwanted access or data breaches increases. Implementing and administering Internet of Things home automation systems may necessitate technical knowledge or professional support. Non-technical users may find it difficult to set up the system, configure devices, and handle connectivity issues, thereby impeding mainstream adoption. IoT solutions rely significantly on consistent internet connectivity to perform properly. Unreliable performance and limited functionality can result from poor network coverage or disruptions in internet connectivity.

III. AVAILABLE SOLUTIONS

The present methods of home automation offered in Sri Lanka are frequently excessively expensive, making them accessible exclusively to the higher class. These systems are often provided by large corporations, so establishing a reliance on them for device integration and limiting consumer options to their unique offers. The limits of this system are obvious, as homeowners must rely on these corporations for any new device additions and are limited to using smart gadgets from the same provider. This lack of flexibility and reliance on a single source can be a big

disadvantage, restricting customers from exploring a broader range of options and tailoring their home automation systems to their unique needs and preferences.

IV. COMPARATIVE ANALYSIS

This study compares various home automation subtopics, such as smart lighting and energy management, security and surveillance systems, home entertainment and multimedia integration, Intelligent Environment Management system and User interfaces and Control mechanisms, in the Sri Lankan context. This paper intends to analyse the methodologies and procedures already used in these domains and determine their applicability and efficacy in Sri Lanka by reviewing a wide range of literature, research papers, and other relevant sources.

The comparative study compares and evaluates the various methodologies, techniques, and technologies utilized in home automation systems. We investigate different systems' functionality, scalability, user experience, integration, and cost concerns in order to determine their strengths, flaws, and places for improvement.

A. Home Automation

This section looks at smart lighting and energy management, security and surveillance systems, home entertainment and multimedia integration, intelligent HVAC systems, and user interfaces. The literature emphasizes developments in these areas as well as their prospective uses in Sri Lankan families. Because we are primarily concerned with the Sri Lankan environment, we must examine aspects such as technology readiness, capital cost, and socioeconomic acceptance of the technology if we intend to extend the system.

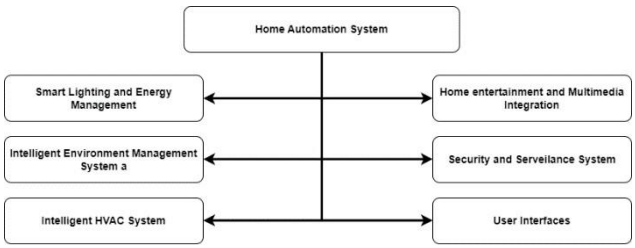

Figure 1. Home Automation System Key Sectors
Source: developed by the author

1) Smart Lightning and Energy Management: Various research articles have extensively studied the implementation of Arduino-based IoT home automation systems for smart lighting and energy control. Devadhanishini provides a successful smart power monitoring system based on Arduino, WiFi, and GSM Short Message Service (SMS). The combination of Arduino with WiFi and GSM technologies allows for effective power monitoring and optimization. A motion sensor is also included to automatically turn off the power supply when no human presence is detected, adding to energy conservation. (Devadhanishini *et al*, 2019).

Rahman proposes a smart energy meter for metering and billing system based on Arduino and GSM technology, which illustrates the integration of Arduino and GSM technology for advanced metering and billing. This system uses GSM modems to transmit data on spent energy and generated bills, as well as security services like line cut/on functionality over the mobile network. (Rahman et al,2015) Another study on an Arduino-based smart light control system demonstrates the use of Arduino in smart lighting control. The system makes use of an embedded platform with a light-dependent resistor (LDR), which allows for effective control and adjustment of illumination intensity in workstations, park lights, and street lighting systems. (Rath, 2016) Diaconu and Deepak Kumar's smart lighting systems both focus on mobile application-based control of lighting systems via Arduino and Bluetooth technologies. Through an Android mobile application, users may control light settings such as power on/off and brightness adjustment. (Diaconu, 2021) (Kumar, Rai and Yadav, 2021)

Furthermore, "Design of Office Intelligent Lighting System Based on Arduino" examines the issues in traditional office lighting systems, focusing on energy saving and indoor illumination appropriateness. The suggested Arduino-based intelligent lighting system monitors and adjusts power supply in real time using electromagnetic voltage control and electronic sensor technology. This system optimizes power usage, minimizes working temperatures, and provides a comfortable lighting environment by avoiding waste, utilizing natural light sources, and combining advanced control algorithms. (Li *et al*, 2020)

A combination of these research findings can be used to construct Arduino-based IoT home automation systems in Sri Lanka. Sri Lanka can reap considerable benefits by combining smart power monitoring, energy metering, and lighting control systems employing Arduino and communication technologies such as WiFi and GSM. These include reduced energy use, more accurate billing systems, increased security, and a more comfortable and sustainable lighting environment.

Finally, the best way for Sri Lanka would be to create an integrated Arduino-based IoT home automation system with smart power monitoring, energy metering, and intelligent lighting management. This would allow for more efficient energy management, less waste, more accurate billing, and a more comfortable lighting environment across the country.

2) Security and Surveillance System: Several research articles provide useful insights and approaches in the installation of an Arduino-based IoT home automation system for smart security and surveillance in Sri Lanka. Sonali P. describes a solution that uses IoT and video monitoring to improve security. The technology detects

motion and recognizes persons, notifying the user via SMS and email. It also reduces waste by adjusting codes for specific appliances. (Gulve, Khoie and Pradeshi, 2017) Gurusha Lulla answers the requirement for a trustworthy security system. This system detects entry attempts with several ultrasonic sensors and allows for remote camera surveillance. Face recognition is used for authentication, and the system may alert the owner if the power goes off. (Lulla *et al*, 2021) Lubab H. concentrates on a low-cost security system that employs Arduino and a cell phone for remote monitoring. It has an infrared sensor that detects motion, collects photographs, and delivers warning signals to the property owner, so improving security. (Albak, Hamed and Al-Nima, 2020)

Nayyar provides an energy management system that includes surveillance functions. The system is controlled by an Arduino UNO and offers cost-effective energy management solutions while including safety features such as fire detection. (Nayyar, Valarmathi and Santhi, 2017) Aditya demonstrates an effective surveillance system based on an Arduino Mega 2560 and PIR sensors. When motion is detected, it captures photographs and delivers push notifications to an Android device. The Near Bus concept enables for remote control of the system, lowering installation costs and increasing energy efficiency. (Sharma and Gupta. 2018)

A combination of these research findings can be used to optimize the construction of an Arduino-based IoT home automation system for smart security and surveillance in Sri Lanka. Integrating features such as motion detection, human identification, remote monitoring, authentication procedures, and power optimization would provide comprehensive security. This would feature real-time property owner notifications, remote surveillance capabilities, and smart energy management.

Furthermore, given the emphasis on cost-effectiveness and energy efficiency in the study papers, it is prudent to select components and technologies that are readily available and cheap in the Sri Lankan market. In the context of Sri Lanka, this technique ensures the system's scalability, accessibility, and sustainability. For Sri Lanka, the best option would be to construct an Arduino-based IoT home automation system for smart security and monitoring. Sri Lanka can improve its security measures while encouraging cost effectiveness and energy efficiency in home automation by combining essential features from research articles such as motion detection, remote monitoring, authentication, and energy optimization.

3) Home Entertainment and Multimedia Integration: Implementing an Arduino-based IoT home automation system in Sri Lanka can revolutionize the way people enjoy entertainment and control their multimedia gadgets in the field of home entertainment and multimedia integration. We can investigate the possible benefits and recommend an appropriate solution for Sri Lanka by drawing insights from the research papers listed.

Yuhui You proposes a gesture-based system that uses the Microsoft Kinect for Windows sensor, Arduino, and Relay Shield to create an immersive ambient entertainment experience. The system can manage ambient lighting, background music, and other visual displays by recognizing user gestures, foot motions, and facial expressions. This technology can be used in Sri Lanka to provide an interactive and engaging home entertainment experience, boosting the enjoyment of multimedia equipment (You, Tang and Wang, 2014). In Sri Lanka, to develop an ideal Arduino-based IoT home automation system for home entertainment and multimedia integration. Sri Lankan households can enjoy a smooth and personalized entertainment experience by adding gesture detection, ambient lighting management, and background music synchronization.

The system can be programmed to detect users' presence using Kinect or similar sensors, causing ambient lights and background music to be activated. Arduino can act as the central controller, receiving sensor information and triggering the appropriate multimedia devices.

4)Intelligent Environment Management System: Smart Home Environmental Monitoring systems, which provide essential data on the surrounding environment, have become increasingly important in our daily lives. This information can be utilized to initiate actions, operate equipment, and maintain optimal living conditions. The following research articles offer light on the creation and implementation of environmental monitoring systems utilizing Arduino and IoT technologies in the context of developing an Arduino-based IoT home automation system in Sri Lanka.

Smart Home Environmental Monitoring systems, which provide essential data on the surrounding environment, have become increasingly important in our daily lives. This information can be utilized to initiate actions, operate equipment, and maintain optimal living conditions. Saima Zafar’s research articles offer light on the creation and implementation of environmental monitoring systems utilizing Arduino and IoT technologies in the context of developing an Arduino-based IoT home automation system in Sri Lanka. (Zafar *et al*, 2018) Given how unpredictable weather changes are, it is imperative to monitor the weather. The goal of this study is to use IoT to build a weather station that can be accessed online. The microcontroller is an Arduino Mega 2560, and sensors to detect temperature, humidity, rain, and air pressure include the DHT-22, FC37 rain sensor, and BMP180. The observed data is saved on an SD card and displayed via an ESP8266

Wi-Fi module on a 2.2" TFT LCD and website. The measures' accuracy is on par with that of a commercial module, making it a dependable method of weather monitoring. (Kusriyanto and Putra, 2018)

With the growing relevance of environmental monitoring, Mr. Deekshath focuses on the role of IoT in gathering data from sensing units. The sensed data is processed and transferred to the ThingSpeak cloud platform using an Arduino UNO and a Wi-Fi module. The data is then saved in a cloud database, and an Android app is created to provide direct access to the measured parameters. This system allows for continuous monitoring of environmental factors as well as a platform for analysis and estimation. (Deekshath et al, 2018) In order to ensure peak performance, Yasen develops a modular environmental monitoring system that keeps track of workplace variables. The Wireless, Main, and Dialer modules make up the system. The Main Module makes use of an Arduino Mega, a number of sensors, a display, LEDs, and audio cues. Using a receiver, the data from the Wireless Module is obtained. The system enables real-time monitoring of numerous parameters and provides SMS notifications in the event of aberrant values (such as temperature or humidity). This technique makes sure that the workplace is secure and beneficial. (Kalinin, Velikov and Markov , 2015)

Combining the ideas from these research papers is advised for implementing an effective Arduino-based IoT home automation system in Sri Lanka. Sensors for temperature, humidity, and other pertinent environmental parameters can be included in the system. To gather, process, and store sensor data, Arduino boards, Wi-Fi modules, and cloud platforms such as ThingSpeak can be used. An easy-to-use user interface, such as an Android app, can enable quick access to measured metrics and allow users to control home automation equipment.

Implementing a Smart Home Environmental Monitoring system based on Arduino-based IoT technology in Sri Lanka can provide useful insights into the surrounding environment as well as intelligent control of home automation devices. Homeowners may successfully monitor and regulate environmental parameters by combining sensors, Arduino boards, Wi-Fi modules, and cloud platforms. Customizing the system to meet unique climate conditions and user needs will maximize its benefits.

5) User Interfaces and Control Mechanisms: Arduino User Interfaces and Control Mechanisms are critical for smart home systems because they provide users with simple methods to engage with their devices and govern their homes. Arduino offers a wide variety of user interfaces that improve functionality and user experience in smart home applications. LCD screens are frequently utilized because they provide real-time data on temperature, humidity, energy consumption, and device status. Users can navigate menus and operate operations by incorporating buttons or keypads.

Touchscreen interfaces are interactive and user-friendly. By tapping or swiping on the screen, users may effortlessly control and monitor devices. These displays allow you to make schedules, alter settings, and view sensor data graphically. Arduino may be combined with mobile applications, allowing users to control devices, monitor data, and access functionality from their smartphones or tablets. They provide remote control, scheduling, energy monitoring, and even connection with voice assistants for hands-free operation. Users can operate and monitor their smart homes through online interfaces from any device that has a web browser. Users can access the interface remotely by hosting a web server on the Arduino board, enabling platform-independent access to real-time data. speech control combines Arduino and speech recognition modules, allowing users to interact with and control tasks via voice commands. It provides a hands-free experience by allowing operations such as lighting control, temperature adjustment, and door locking.

These Arduino user interfaces can be combined or connected to form sophisticated control systems. A system, for example, could use a smartphone app for remote control and an LCD display with buttons for local control. The interface chosen is determined by system complexity, user preferences, and special requirements.

V. CONCLUSION

The advantages of implementing Arduino-based IoT home automation systems in Sri Lanka are significant. Home automation can optimize energy consumption, lowering utility bills and relieving load on the national power infrastructure. Irrigation automation has the potential to transform agricultural processes by maximizing water use and increasing crop yields. Waste management automation can improve waste collection and disposal efficiency, resulting in a cleaner and healthier environment. Finally, healthcare automation can allow for remote patient monitoring and prompt interventions, hence increasing healthcare access and results.

The specific characteristics of each household will have an intrinsic impact on how the home automation system is architecturally designed. These variables could include elements like the physical design of the house, the kinds of automated appliances and gadgets, user preferences, and particular energy use patterns. In order to properly align with the unique requirements of each household while keeping a cogent and effective framework, the system design must be adaptive and adjustable to suit these diverse characteristics.

This comparative analysis' findings have practical significance for Sri Lankan homeowners, researchers, and practitioners interested in deploying IoT-based home automation systems. We can establish the viability and potential problems connected with adapting and executing them within the specific socio-cultural and technological landscape of Sri Lanka by discovering and studying approaches already used in other situations.

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