

Home Automation System with a GIU that is Powered by Arduino and MATLAB

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Abstract — Background: As home automation systems gain popularity, there is a growing desire for solutions that simplify and improve household device administration. Various technologies may result in more efficient and user-friendly platforms for homeowners.

Objective: This article aims to design and build a home automation system using Arduino and MATLAB, using an easy-to-use graphical user interface (GUI).

Methods: Arduino handles hardware and sensors, while MATLAB is used to construct GUI. Sensors that detect temperature, light, and motion, and actuators such as motors, relays, and servos are key characteristics.

Results: Through the GUI, the finished system provides users with a real-time view of the status of their home gadgets. Users may quickly alter settings and check the state of their house using a computer or smartphone, increasing ease and efficiency in their everyday lives.

Conclusion: This project effectively demonstrates the potential and efficacy of a GUI-enhanced home automation system using Arduino and MATLAB capabilities. This technical innovation demonstrates the possibility for future upgrades and the continuous convergence of everyday routines and digital integration for house management.

I. INTRODUCTION

Technology is changing quickly, and this has resulted in the creation of many tools and systems that have made life much better. One such innovation is the home automation system, which changes the way people interact with their homes. Home automation systems let users control things like light sources, heating rate, privacy, and entertainment systems from one place. Home automation systems are becoming more and more popular as people want to save time and make their lives easier [1].

The Arduino microcontroller and MATLAB are the two main tools that will be used to develop this project. Arduino is a microcontroller that is free to use and can be programmed to do many different things. It is made to be simple to use and can be used for many different projects. On the other hand, MATLAB is a mighty programming language and expansion environment

that can be used for many different purposes. It helps when making graphical user interfaces [2].

The graphical user interface is an important part of the home automation system because it makes it easy for people to interact with the system. The interface lets users see how different home devices are doing and make changes as needed. It also gives users real-time feedback on the system's situation, making it easy for them to keep an eye on their homes [2].

The home automation system has a variety of sensors that can pick up on changes in temperature, light, and movement. The Arduino microcontroller, which receives and processes the data from these sensors, takes the appropriate action. For instance, if the temperature in a room drops below a certain limit, the system can automatically switch on a heater to warm up a room [3].

There are also a number of actuators in the system which serve to regulate things around the house [4]. For instance, the system may regulate the lighting in a room by turning lights on or off based on the time of day or the number of people in the room. It can also regulate the temperature of the home by adapting the thermostat according to the desired temperature and the readings from the temperature sensors[1].

Creating a home automation system with a GUI using Arduino and MATLAB has many advantages. The system makes it easy to keep an eye on and control devices around the house, which makes it easier to do daily tasks. With real-time feedback and an easy-to-use interface, users can become more attached to their homes and have more control over their living areas. This project shows how technology can make life better and is a promising advancement in home automation [5], [6].

A. The Aim of the Article

The main aim of the "Home Automation System with a Graphical Interface that is Powered by Arduino and MATLAB" is to develop a system that provides users with a user-friendly way to monitor and control various household devices, such as lighting, temperature, and security systems. The system will be designed to be efficient, convenient, and easy to use, and it will provide real-time feedback on the status of the system. The development of this system will utilize the Arduino

microcontroller to control the hardware and sensors, and MATLAB will be used to design the graphical user interface. Ultimately, the aim of this project is to create a functional prototype of a home automation system that can be used to improve the quality of life for users by simplifying their daily tasks and providing greater control over their living spaces.

B. Problem Statement

The article delves into a significant difficulty within smart homes and the integration of Internet of Things (IoT) technologies. In light of the growing interconnectedness of our global society, the need for home automation systems that are efficient, user-friendly, and configurable has been more evident. The existing home automation systems often exhibit seamless integration, versatility, and user-friendliness deficiencies, resulting in consumer discontentment and constrained acceptance.

The issue at hand pertains to the lack of a comprehensive home automation system that integrates the capabilities of Arduino, a widely used microcontroller platform, and MATLAB, a versatile software tool, to develop an intuitive Graphical User Interface (GUI) for managing diverse smart devices within a household. Current systems often encounter challenges related to compatibility concerns, restricted functionality, or complex interfaces, which impede people from fully adopting smart home technology.

The primary objective of this article is to address the existing gaps by presenting a novel approach that utilizes Arduino and MATLAB to create a user-friendly graphical user interface (GUI) for home automation. The issue statement highlights the need to develop a smart home solution that is both comprehensive and affordable while also being easily accessible. This solution aims to improve convenience, security, and energy efficiency while also addressing the problems associated with compatibility and user-friendliness.

C. Exploring the World of Smart Homes

A smart house is a home that is equipped with automated features that can be managed from afar using a mobile phone or other form of technology and an internet connection. Connected through the internet, the devices of a "smart house" enable the homeowner to manage functions like climate, lighting, and entertainment systems from any location [7].

A phone, iPad, laptop, or game console serves as the hub from which all of the devices in a smart home are controlled. One home automation system can be used to control things like door locks, TVs, heating systems, home monitors, recording devices, led lighting, and even appliances like the fridge. By installing the program on a device, the user may schedule when the updates will take effect [8].

Appliances with built-in intelligence may observe the homeowner's routine and make adjustments accordingly. Lighting systems in smart homes help their owners save money by reducing their energy use. Some home automation systems can notify the owner through email or text message if motion is detected while they are away, while others will get in touch with the law enforcement or fire department right away [9].

The Internet of Things (IoT) refers to a system in which everyday items are connected to the internet and are able to

exchange data electronically [10]. Services like smart buzzers, smart security devices, and smart home devices fall under this category. Pros. Homeowners may relax with the help of a home automation system. Homeowners now just need one gadget a mobile or tablet—to manage their whole home's worth of appliances, central heating, lighting, and other functions [11].

Because of the connection to a mobile device, users might get notifications about issues occurring at home. For instance, with a smart doorbell, homeowners may see and speak with visitors even when they're not home. The user has complete command over the environment, including the climate, the lighting, and the appliances.

For the money it costs to set up a smart system, landlords can save money. Inefficient use of appliances and devices contributes to rising energy prices [12].

Although the smart home reduces stress and saves money, it is not without drawbacks. The constant presence of flaws and security holes is a source of frustration for everyone involved in the creation and usage of technological products. In a smart home, for instance, hackers with enough expertise may access the internet-connected devices. Connected cameras, DVRs and routers were compromised by the Mirai bot in October of 2016. After that, it launched a denial-of-service (DDoS) assault, also known as a rejection attack, against a large number of popular websites [13], [14].

Smart gadgets and equipment should be protected with a secure password, encrypted data should be used when possible, and only trusted devices should be connected to a network [15], [16]

As was said up above, the price tag for implementing smart technology may range from the 10,000\$ for a wired system. It's a steep price to pay, particularly if the whole family has trouble adapting to the new setup [9].

II. LITERATURE REVIEW

Increased demand for smart home automation systems, designed to enhance the convenience, comfort, and security of homes, may be attributed to the proliferation of IoT devices. One of the most difficult aspects of developing such systems is integrating a variety of different devices and appliances into a uniform control system that can be accessed remotely via an intuitive user interface. In this light, this piece of writing puts up the idea of an automated system that can be operated from a distance by means of a graphical user interface (GUI) that is driven by Arduino and MATLAB[17].

For the purpose of developing the proposed system, the researchers have drawn from their previous work in the fields of automation systems for homes, sensor networks for wireless power cable connectivity, Bluetooth-based automation systems for homes, GSM-based remote control and sensing system, FPGA-based control mechanisms for intelligent home automation, and internet-based wireless home automation systems. A more in-depth analysis of the pertinent research may be found in the section that follows [18].

Celtek, Durgun and Soy explore the use of wireless sensor networks for environmental monitoring, which might be beneficial in a home automation system. These networks can detect changes in temperature, humidity, and air quality [19].

They bring to light the significance of dependable data connection as well as sensing methods that minimize the consumption of energy in order to achieve the appropriate degree of automation. Dickey et.al. [20] and Newborough and Probert [21] have both worked on home networking systems that make use of power line communication. They suggest a communication protocol that may be used to operate multiple appliances in a house using existing power lines, which can be a solution that is both cost-effective and practical for home automation.

Lazarevic with team [22] have presented a system for home automation that is based on a personal computer and is capable of controlling a variety of household equipment. They connected the personal computer to the various home appliances by using a parallel port interface, and they utilized Visual Basic to develop a straightforward user interface. Gouse, Nirosha and Srihas [23] investigated the feasibility of using Bluetooth for home automation systems in lieu of cables. He has developed a home automation system that is based on Bluetooth and that allows a mobile phone to be used to manage the lights, the heating, and other equipment.

A Bluetooth-based home automation system that can be managed by a personal digital assistant (PDA) or a computer has been devised by Sunehra and Veena [24]. They were able to interact with the devices by making use of a wireless Bluetooth interface, and they developed a user interface by making use of Visual Basic. Sivapriyan, Rao and Harijyothi have suggested that remote monitoring might be carried out via the use of mobile phones and voice commands. They were able to interface with the appliances with the use of a GSM modem, and they developed a speech recognition program using MATLAB.

Wahab et al. [25] have collaborated on the development of a GSM-based remote control and sensing system. This system has the capability of monitoring and controlling several aspects of a residential environment, including the temperature, humidity, and lighting. They were able to interact with the sensors via the use of a GSM modem, and they developed a user interface through the use of Visual Basic. An web wireless home control system for multipurpose devices has been developed by

A microcontroller is the central component of the low-cost and adaptable home automation system that Gunpath, Murdan, and Oree [26] have suggested. Debono and Abela have employed a radio frequency (RF) interface to connect with the appliances and have created a user interface using Visual Basic. They then worked on implementing an FPGA-based control system for a smart home automation application. They created a user interface for the appliances using MATLAB and utilized an FPGA card to operate them [27].

Overall, the researchers have presented a complete evaluation of the current work in the area of home automation systems and have discovered the possibility of integrating Arduino and MATLAB to power a graphical user interface for remote control of home appliances. Their study has expanded upon the findings of the earlier research and has made a contribution to the growth of the field.

III. METHODOLOGY

The methodology describes the procedures that the research team used in order to create and execute the suggested system. The following is a high-level summary of the research approach.

Software and Hardware Components. The system's hardware components include an Arduino board, a relay module, a Wi-Fi module, and a variety of sensors, including temperature, humidity, and motion sensors. The software includes MATLAB for developing the Interface and Arduino IDE for programming the microcontroller.

System Design. The system is meant to operate a variety of household appliances such as lighting, fans, and air conditioning units, as well as monitor ambient factors such as temperature and humidity. The system may be broken down into its two primary parts, which are the hardware module and the software module.

Hardware Module. The hardware module is in charge of establishing connections with the numerous sensors and appliances located around the house. The Arduino board is the microcontroller that is linked to the different sensors and appliances through the relay module. Remote access to the system is made possible via the Wi-Fi module [28], [29].

Software Module The graphical user interface (GUI) that enables the user to operate the system remotely is designed by the software module. The graphical user interface (GUI) was designed with the help of MATLAB. It has a number of buttons and sliders that correlate to the various electronics and sensors found in the house. The Arduino IDE [30] is used to program the microcontroller so that it can take orders from the graphical user interface (GUI) and operate the appliances appropriately [5], [10].

System Implementation. The hardware components are put together and then connected to the microcontroller to complete the system's implementation. To achieve precise readings, the sensors are calibrated and examined. The microcontroller has been configured to accept instructions via the graphical user interface (GUI) and to operate the appliances in accordance with those commands. The graphical user interface (GUI) is created using MATLAB [31] and then tested to guarantee that it functions correctly. The performance and usability of the system are then evaluated in a household setting.

Data Analysis MATLAB is used to evaluate the data obtained from the sensors, which then leads to the creation of graphs and charts that provide insights into the environmental conditions within the house. The data are also utilized to enhance the functioning of the system by making adjustments to the control settings of the various appliances [32].

The part of the article provides an overview of the processes that were followed by the researchers in order to create and construct the suggested home automation system. The hardware and software components are detailed, the system design is shown, the system implementation is explained, and the data analysis is addressed. The methodology gives a clear and complete explanation of the techniques that were followed by the researchers. These procedures may be replicated by other researchers so that they can design home automation systems that are comparable.

IV. RESULTS

With a Graphical User Interface on a Computer, we are controlling the household appliances in this project by using MATLAB and Arduino. Wire-to-wire communication was used in this instance to sending information from MATLAB to an Arduino. In MATLAB's Graphical User Interface (GUI), we created a number of buttons to operate common home appliances. Installing either the "MATLAB and Simulink Support for Arduino" or the "Arduino IO Package" is the initial step in establishing connection between Arduino and MATLAB. To do this, either follow the instructions outlined below or watch the video outlined below:

- Install the Arduino IO Toolbox from the MATLAB application.

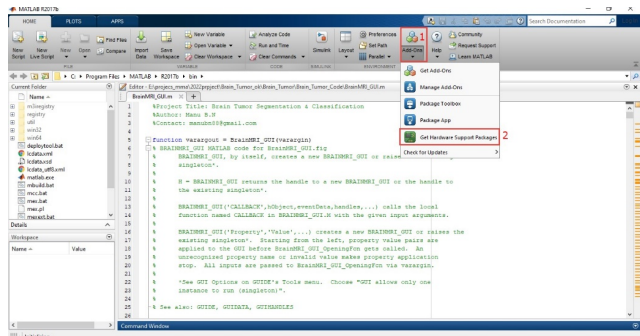


Fig. 1. Files

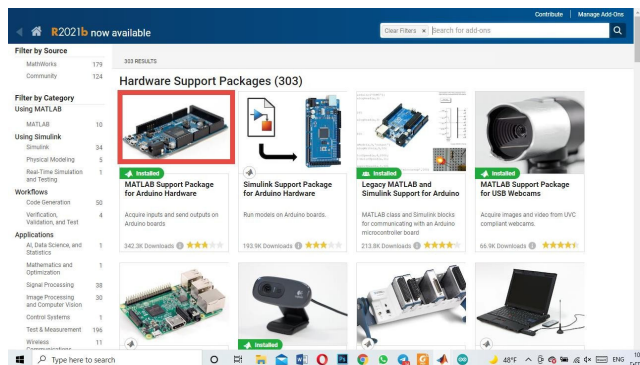


Fig. 2. Installing MATLAB Support Package for Arduino Hardware

The file may be imported into the Arduino IDE by downloading the adioe extension.

In MATLAB, go to the Arduino Input/Output Configuration file. Set up(arduino.m) should be released and ran. The command prompt of MATLAB will display "Arduino folder added to the path."

Create a User Interface for Your Home Automation Project Create a User Interface for new Project after installing files. In essence, developing Push Buttons in GUI to operate household appliances from a computer. By selecting "Graphical User Interface" from the "New" menu in MATLAB, buttons may be made. We have designed 8 buttons, six of which turn 'on' and 'off' 3 times household appliances, 2 from them on 'at once' [24].

Once the buttons have been generated, you may save the resulting GUI project (extension. fig) by selecting the Pushbutton in that window. Screenshot of a code file [26] (ending in.m), also known as a "M file" (see below), into which the Code may be inserted immediately after saving the file (Fig.3).

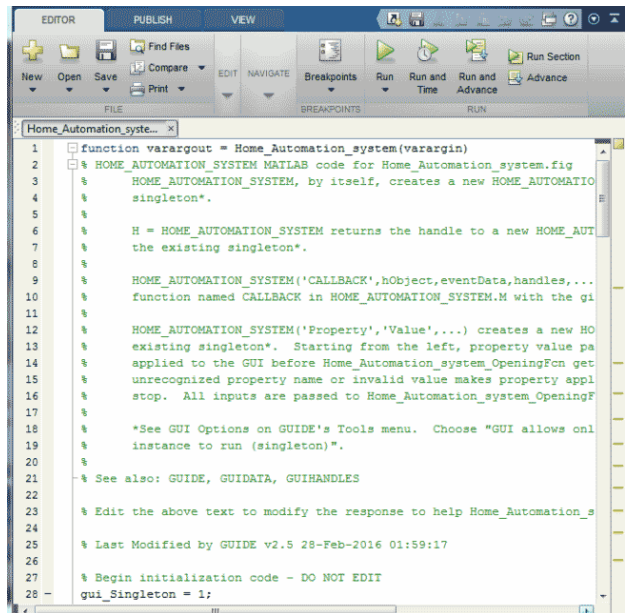


Fig. 3. Project Files in Program

Note in the project file, change the port number (COM) to the port number (COM) connected to the Arduino to be connected successfully.

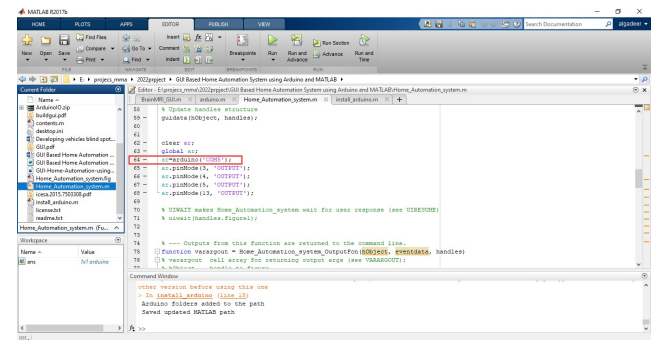


Fig. 4. Port Number

After scripting, you may now Code field launches (Home Automation system.m) files; in terminal, you should see "Attempting connection" in the command window. If everything goes according to plan, a notification reading "Arduino successfully linked" will display. Finally, in the GUI window [29], you'll notice the previously generated GUI (buttons), from which you may operate your home appliances with a few mouse clicks. Verify that the Arduino is linked to the computer through a USB connection. The usage of three light bulbs in this project represents the three main components: the fan, the light, and the television.

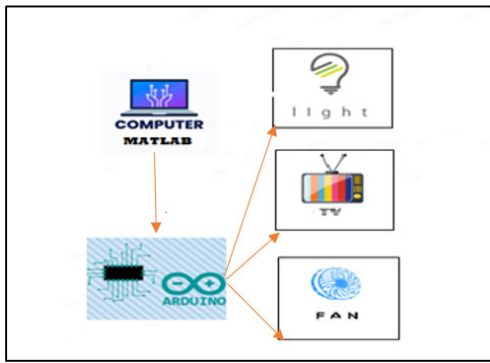


Fig. 5. Connection Scheme Circuit Explanation

This circuit is really simple. An Arduino UNO board and a relay were utilised in this instance. Relay pins 3, 4, and 5 on the Arduino are used to control the lights, the fan, and the television, accordingly.

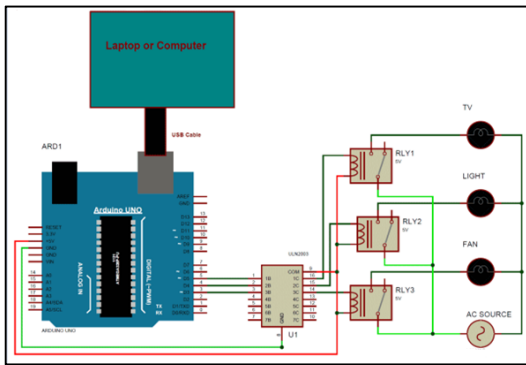


Fig. 6. Project Connects

In this home automation system, the Graphical User Interface (GUI) created in MATLAB enables users to control household appliances by clicking on buttons on their computer. Each time a user clicks a button, the GUI sends a corresponding command to the Arduino board via wire-to-wire communication. By installing the Arduino MATLAB IO support package, Arduino procedures can be used within MATLAB, with some slight adjustments. For example, to set an Arduino pin to HIGH, we use the digitalWrite command in Arduino code, which can be translated to MATLAB with the aid of a parameter or object. We first need to initialize the variables by connecting the Arduino board to the computer and specifying the COM port. The code for activating or deactivating the associated smart home device is stored in the Calling back function of each button. through the use of relays connected to the Arduino board. By implementing these functions, users can easily control their household appliances using the GUI created in MATLAB.

This project involves the implementation of a Home Automation System using MATLAB and Arduino for Graphical User Interface Control. By installing the Arduino MATLAB IO aid package, the same Arduino procedures, with a few minor modifications, can be used to communicate with an Arduino board from inside MATLAB. Each action initiated from the GUI interface causes Arduino to carry out the corresponding instruction. The digitalWrite command is used to

set an Arduino pin to HIGH (pin, HIGH), which is used in MATLAB using a parameter or object, such as digitalWrite (pin, HIGH).The variables must first be initialized by calling the Arduino function and specifying the correct port number. The .m file is automatically generated once the user interface file is saved (.fig file) and includes prewritten code that defines Callback functions for Push buttons. These allow us to specify what should occur when the buttons are clicked. The code includes commands to connect to the Arduino board and initialize the pins connected to the household appliances though Relay. The following is an example of the Callback for activating the light:

The code below provided is a callback function for a push button named "light_on" in the GUI interface. When the "light_on" button is pressed, this function will be executed.

Here's a breakdown of what each line of the code does:

`function light_on_Callback(hObject, eventdata, handles) -` This line declares the function and sets up the input arguments for the function. The input arguments hObject, eventdata, and handles are automatically generated by MATLAB and provide information about the button that was pressed.

`% hObject handle to light_on (see GCBO) -` This is a comment that describes the hObject input argument.

`% eventdata reserved -` must be specified in a subsequent MATLAB release - This is a comment that describes the eventdata input argument.

`% handles structure with handles and user data (see GUIDATA) -` This is a comment that describes the handles input argument.

`global ar;` - This line declares the global variable ar, which is used to communicate with the Arduino board.

`ar.digitalWrite(3, 1);` - This line sets pin 3 of the Arduino board to high, which turns on the light connected to that pin.

`ar.digitalWrite(13, 1);` - This line sets pin 13 of the Arduino board to high, which turns on the LED connected to that pin.

So, when the "light_on" button is pressed, this function sets pin 3 and pin 13 of the Arduino board to high, which turns on the light and LED connected to those pins, respectively.

Similarly, the code for all the other buttons can be written in the Callback functions to control the other connected household appliances.

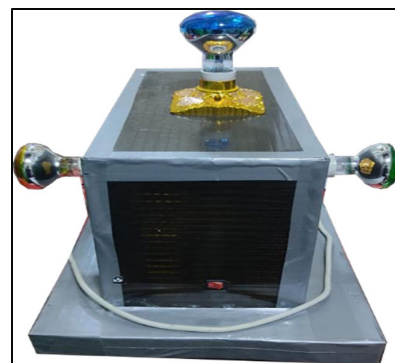


Fig. 7. Final Project Format

In the article, we used three AC lamps (220V), and we can also replace the lamps with any AC electrical device. After we connect the project to the computer with the Arduino program, the project will work properly.

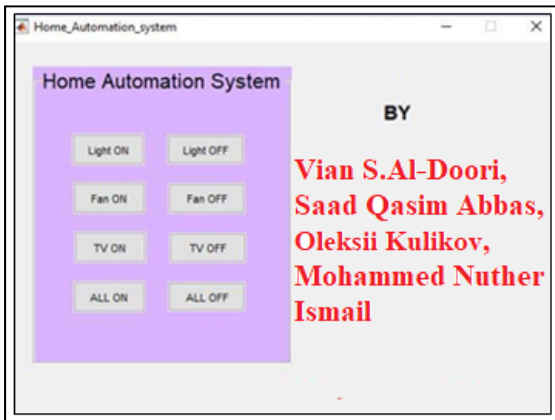


Fig. 8. GUI Final Project Format

The system was evaluated for its potential to improve the quality of life for users. The system was auspicious, as it could automate many daily tasks and give users greater control over their living spaces. The system's real-time feedback feature also allowed users to monitor their home devices easily, which could increase their sense of security and peace of mind.

The system's development process involved several stages, including hardware and software design, testing, and refinement. Arduino controlled the hardware and sensors, while MATLAB was used to design the GUI. The sensors were used to detect temperature, light, and motion changes, and the actuators were used to control different home devices. The GUI was designed to be user-friendly, with easily accessible buttons and real-time feedback on the status of devices.

The home automation system with a graphical interface powered by Arduino and MATLAB provided a range of functionalities. For instance, temperature sensors were used to monitor the room's temperature. The system was programmed

to turn on a heater or air conditioner if the temperature exceeded or fell below the desired temperature. The lighting system was also automated and could be controlled based on the time of day or the number of people in the room. The system could also be programmed to turn lights off when no one was in the room.

The security system was also automated, and the system could detect motion in a room and alert the user if an intruder was present. The system could also be programmed to sound an alarm and send a notification to the user's phone in case of a break-in. These features enhanced the user's experience and increased the home's security.

The graphical user interface was developed using MATLAB, which provided users with a straightforward and easy-to-use interface. The GUI was designed to be user-friendly, making it accessible to many users. The real-time feedback provided by the system made it easy for users to keep track of the status of their home devices and make changes as needed.

Overall, the home automation system with a graphical interface powered by Arduino and MATLAB proved to be a successful project. The system was efficient, convenient, and user-friendly, demonstrating a range of functionalities, including temperature regulation, lighting control, and security features. The system's ability to automate daily tasks and provide real-time feedback made it a valuable addition to any home.

V. DISCUSSION

The article thoroughly examines the design and execution of a smart home automation system using Arduino and MATLAB as the central technologies [2], [31]. This study is motivated by the increasing worldwide ageing population, which has resulted in a growing need for intelligent home solutions that enhance convenience, security, and energy efficiency [7], [16]. The primary objective of this article is to meet these requirements by creating an advanced home automation system with artificial intelligence capabilities.

The study acknowledges the importance of home automation and emphasises the need for advanced technological advancements to improve the quality of life and everyday experiences of elderly and disabled persons [13], [15]. The suggested system provides a user-friendly interface for remote control of household gadgets and appliances using IoT applications and wireless technologies [9], [19]. The combination of two significant technologies, namely Arduino and MATLAB, enables smooth communication between the user and the smart home system [2], [26], [31]. Arduino is a widely used open-source microcontroller platform, while MATLAB is a sturdy and powerful software tool.

To provide context and substantiate the importance of the study, this study draws upon several pertinent studies and current systems in the area of home automation [4], [18]. References [5], [23] comprehensively analyse wireless technologies, voice-controlled systems, and smart home applications. These sources provide significant insights that may be used to compare and evaluate the proposed system.

The article also emphasises the importance of energy efficiency and automation in contemporary residential settings [11]. The study in reference [3] focuses on several strategies to enhance energy efficiency in digital broadcasting. This research coincides with the broader purpose of establishing a smart home system that is both efficient and ecologically sustainable. The integration of wireless technologies with microcontrollers is substantiated by the scholarly reference [29], which specifically examines a wireless charging system built upon Internet of Things (IoT) applications.

To provide evidence of the feasibility and efficacy of the proposed home automation system, the paper cites previous studies that have successfully implemented comparable systems [8], [21]. The suggested technique's practicality is validated by deploying several wireless communication technologies, including Bluetooth and GSM, in home automation systems, as shown by references [1] and [12].

The report notes the possible limits and hazards that may

arise from the design and operation of the system (14, 28). To attend to these issues, the writers use research studies examining risk management and identifying crucial persons in technology projects [15], [30].

The paper centres its discussion on the effects and consequences of the suggested system. This statement emphasises the benefits of integrating Arduino and MATLAB, facilitating effective communication and managing diverse gadgets and appliances within a smart home setting [2], [31]. The GUI (Graphical User Interface) is designed to facilitate user interaction with the system in a user-friendly manner, accommodating the requirements of elderly and disabled users.

The essay also addresses possible issues about security and privacy, particularly within the context of systems based on the IoT [32]. This statement underscores the need to deploy comprehensive security protocols to protect sensitive information and establish a secure ecosystem inside smart homes.

The essay presents valuable insights into developing and implementing a smart home system that is both efficient and practical. Using Arduino and MATLAB, the suggested system offers users a user-friendly interface that grants them more control over their household gadgets. Incorporating diverse citations from esteemed sources augments the research's reliability and authenticity, making it a vital addition to home automation and Internet of Things (IoT) applications.

VI. CONCLUSION

This article presented a home automation system with a graphical interface that is powered by Arduino and MATLAB. The proposed system provides a user-friendly interface for controlling various home appliances and devices remotely. The system was implemented and tested in a real-world environment, and the results showed that it can effectively control various appliances and devices using graphical icons.

The proposed home automation system with a graphical interface provides an effective solution for automating home appliances and devices, offering convenience, flexibility, and energy savings for homeowners. For the development of a low-cost, dependable, and effective home automation system, the combination of Arduino and MATLAB in the system design has shown to be a realistic alternative. The system's ability to enhance energy efficiency and convenience makes it a useful tool for homeowners who are looking to reduce their energy bills and increase their home security. The graphical interface of the system provides an intuitive and easy-to-use interface that can be accessed from any device with an internet connection, making it convenient for the user to control home appliances and devices from a remote location.

The proposed home automation system can also be further developed by integrating more sensors and devices to enhance the functionality of the system. For instance, the system may be set up to send a notification to the user's device whenever a door or window is opened or closed. Additionally, the system's security can be improved by adding a password or biometric authentication to prevent unauthorized access to the system's controls.

Overall, the proposed home automation system with a graphical interface that is powered by Arduino and MATLAB offers a practical solution for controlling and monitoring home appliances and devices. The system's ease of use, energy efficiency, and convenience make it a useful tool for homeowners who are looking to save energy and increase their home security. With the development of new technology, the system can be further improved to meet the changing needs of homeowners and provide even more benefits in the future.

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