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Implementation of Secure Home Automation with Field Programmable Gate Array

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Abstract- In a society where individuals strive for as much comfort as possible, new technologies have been invented to make their lives simpler. Secure Home automation is an area with many opportunities that is emerging as a supplement to the traditional use of electronic equipment such as lighting accessories, air conditioning systems, or even curtains, which allow a degree of independence by incorporating sensor equipment, aiming for efficiency and smart performance. A low-cost smart person detection system is given, which includes the deployment of a PIR sensor and its connectivity via an Enable button, which allows the user to get notifications whenever the sensor detects presence. Secure House Automation is the intelligent control of electrical and electronic devices in a home, business, or building. A home automation system project is created in order to regulate two critical factors of a house's security and comfort. Lighting and temperature control are two examples. The fire and intruders are detected by the security system through the entrance, window, and garage. The core of each smart home project is the design of digital systems. This project allows you to regulate the comfort and security of your home. In this research, a Verilog code is used to construct a Smart house with Security. Interfacing devices and sensors to the Field programmable gate array, abbreviated as FPGA, regulate security and comfort. The Verilog code was created using the Xilinx platform.

Keywords: Secure Home, Internet of Things (IOT), PIR Sensor, Hardware Implementation, FPGA, Xilinx, Verilog

1. INTRODUCTION

Technology allows us to connect globally and share information in seconds. Wireless Communication is chosen over cable communication since it is faster and easier to access with new technologies. Technology also assists us in being more at ease and approaching our everyday tasks in the most efficient manner possible. IoT technology is the most efficient and user-friendly method of communication. IoT may be accessible by IP address as well as over the web. IoT modules are less expensive than Bluetooth modules and can provide sufficient output with less mistakes[5]. Home automation is the process of accessing your domestic appliances via the ESP 8266 is the IoT module utilized in this project(NodeMCU). When combined with an FPGA board, IoT provides not only easy and flexible communication but also boots the security of the data exchanged. The FPGA board utilized here is the EDGE Artix-7. FPGA also has a high output where numerous applications may be developed to assist us transform our home into a smart home. Long-distance communication can also be created between the user and the home appliance. Security concerns are the most perplexing challenges that have arisen in front of every individual in the current environment. So, in this sort of circumstance, there must be some Smart remedies for them. In this work, we attempt to provide a highly clever solution for home security. This method will improve security in homes, banks, and other institutions. There have been several occasions when crime has occurred as a result of a lack of security. Criminals prefer to commit such crimes in abandoned homes, banks, and other institutions. To use this system, we use an enable pin to turn on and off the security alert system. It gives an alert notification on the to the end user and on the web application also.[6]

People now a days are chasing an ever-increasing high quality of life while simultaneously contemplating pandemic concerns, social distance, and personal hygiene. Conventional electric switches are

often positioned in various corners of the home, necessitating the use of manual procedures such as pushing to turn electrical loads on or off. This became challenging for the elderly or physically challenged to operate them. This results in additional amenities and residential appliances being incorporated in locations where the control is convenient and simple to operate. High security and error-free equipment are equally important aspects of their life nowadays. A web and android application are used to operate numerous electronic items in this work.

The System is intended to control lighting, fans, and household appliances. It isn't meant or configured to control anything else. This project is being created to control only these devices, but it can be expanded to control other devices in the future. In the Security alert aspect, it may be improved further by taking images and transmitting them to the end user.

2. MATERIALS AND METHOD

2.1 Secure Home Design

This Secure home system has a variety of features. The sensor system consists of a number of sensors, including LDR, PIR, and an ESP8266-12F module. If any sensor is sensed from the sensor transmitter, a signal is transmitted to the receiver FPGA board, which further sends a signal to the wi-fi module so that the data can be viewed on a web application using the Think Peak software by the Internet of Things. Motion detection with security warning is another feature of the Safe Home system[7]. This system uses one PIR motion sensor as well as a buzzer. The motion sensor will automatically start alerting the end user with a buzzer sound and begin uploading the data to the internet of things through the ESP8266-12F when the criminal gets inside the residence.

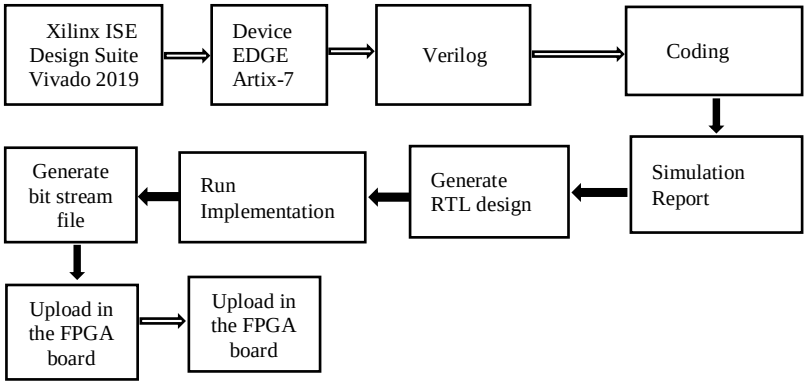

Figure 2.1. Block Diagram of Secure Home Automation

Before to designing (coding) a programme and testing hardware and sensors, the fundamental idea is to methodically define the path. The steps of the software simulation are listed below. The process of executing the programme while synthesising XST to check for programme problems, looking at the RTL, implementing the design, creating a programming file, configuring the target device, and finally running the programme are shown in a block diagram in Figure 1.

2.2 Design Flowgraph

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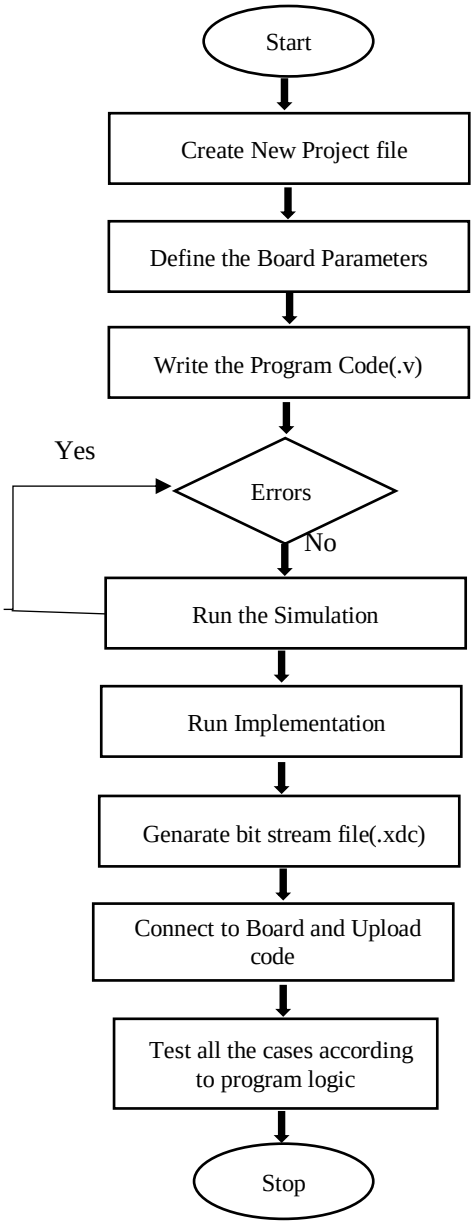

Figure 2.2 Design Flowgraph

At first you need to create a new project file with any name. Later you need to define all the hardware board parameters in Xilinx vivado tool. Next, you need to write the program code according to the project logic. Check for any errors if errors found rectify the errors and after rectifying the errors run the simulation. Later you need to Run the implementation part in the project window. After completion of Implementation part generate bit stream file (.xdc file). Connect to the Hardware board i.e., EDGE Artix-7 by supplying power to it. Now check all test cases for the project logic. If doesn't work search for the errors and rectify the error and do same process discussed above.[8]

3 RESULTS AND DISCUSSION

3.1 Implementation of PIR sensor

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In this scenario, i.e., we are employing an enable as an input switch to assess Security System is to be function or not. It emits an alert sound whenever the user activates Security System, and when pir detects motion, i.e., high, then the buzzer emits a beep sound alarm. PIR functions on the theory of whenever it detects a change in infrared radiation, it generates a digital output signal.[2]

3.2. Implementation of LDR sensor

In this case, LDR sensor detects the ambient light and generates an analog voltage signal. The FPGA converts the analog signal to a digital signal for processing. The FPGA then compares the digital signal to a predefined threshold value to determine if the street light should be turned on or off. If the ambient light is low, the FPGA will turn on the light. If the ambient light is high, the FPGA will turn off the light. The FPGA constantly monitors the LDR sensor's output and adjusts the light accordingly. The FPGA can be programmed to adjust the threshold value, ensuring the light is on only when necessary. This results in energy efficiency and reduces costs associated with manual operation of home appliances lights.[4]

3.3 Implementation of Light and Fan

Here in this case, we are implementing 'Switch1' as Switch of Lights to regulate the operation of light as "ON and OFF". In this condition, when switch1 is 1 (high), the LED light turned on, and when switch1 is 0 (low), the LED light goes off. In this application, LEDs are used as household lights. And similarly for the implementation of Fan we are using 'Switch2' as switch of Fan to regulate the operation of Fan as "ON and OFF".[9]

3.4 Implementation of Warning Indicator

Here in this scene, we want showcase the warning indicator if any of the house hold appliances is in 'ON' condition it just simply indicate red Led light that tells us something in the house hold appliance is ON and that to be turned off while your leaving your home. This application is very useful when are leaving the house and we can directly off the all the components in the house if any of the thing is ON.

3.5 Implementation of Wi-Fi Module

The EDGE Board includes an on-board ESP8266 12F WIFI Module that is serially coupled to the Artix-7 FPGA. The ESP WIFI Modem facilitates communication between the FPGA and the cloud. AT Commands can be used to save and retrieve data from the cloud. The communication range of a WIFI modem is 50-100 meters. Place a jumper at Enable and the center pin of J3 to enable power supply to the WIFI Modem. To turn off the power, connect the jumper to Disable and the center pin of J3. For testing and firmware updates, the J2 connection received the TX, RX, and GPIO0 lines of the ESP12F WIFI module.[10]

3.6. Simulation Report

From the below figure we can observe that buzzer state is High i.e., 1 only when PIR state is 'High' and enable switch is also 'High'. Buzzer does not work if PIR state is High and Buzzer doesn't work if any of PIR and enable is Low state i.e., '0'

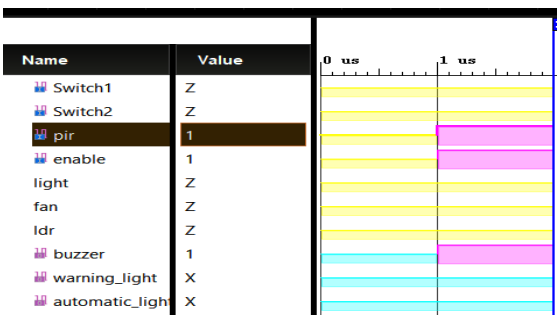

Fig 3.1. Implementation of PIR

3.7. Simulation Report-2

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Here we can see that manual Light and Fan will be in High state when the switch 1 and switch 2 are in the 'High' state correspondingly. If any of the switch is in 'Low' State then the respective appliance will be in off state i.e, Low state.

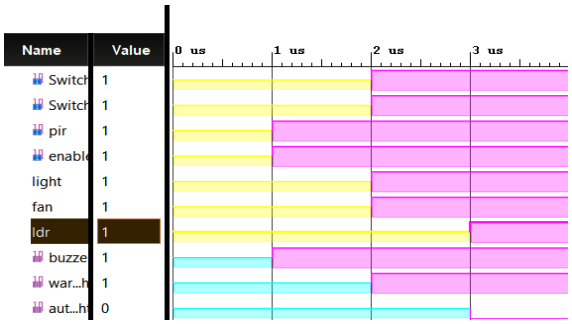

Figure 3.2. Implementation of Home appliances

3.8 Secure Home Report

We will see the full secure home automation and it's working according to its application discussed in the above implementation part. In this case we can also observe the operation of automatic light using ldr_module. It's works on the principle of intensity of light that fall on the ldr module.

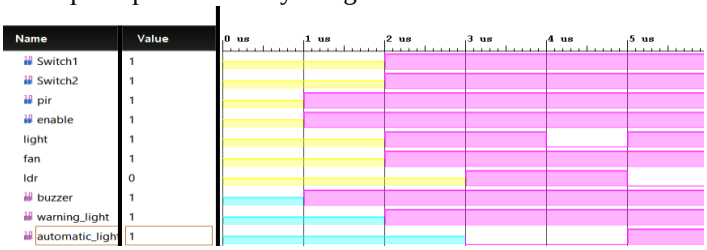

Figure 3.3. Full Secure Home automation Report with ldr_module

3.9 Hardware Implementation

Here we will connect the PIR sensor to one of the GPIO pin and similarly we will connect the ldr_module by declaring it on the in-built board and buzzer can be used from the Board. Later We need to connect the Light and Fan by connecting it to the GPIO pins. And finally Switches also can be used from the FPGA board. For implementing the Hardware parts we need to declare each and every component that we declared in the program code i.e, (.xdc file)[11]

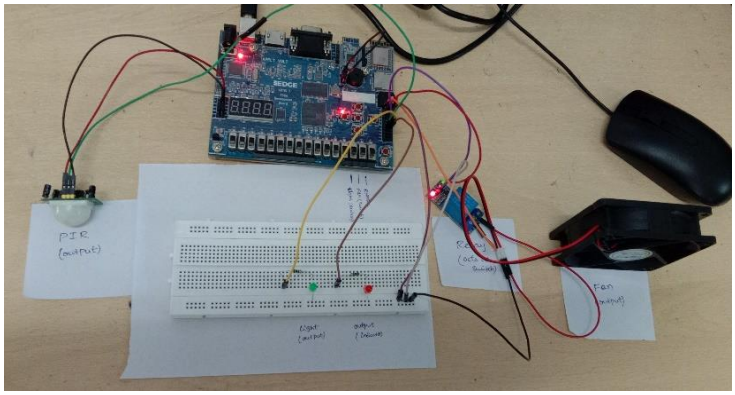

Figure 3.4 Hardware Implementation

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3.10. Summary of Secure Home automation

Here we have consumed 3 LUT's out of 20,800(0.01%) and we have used total 10 I/O ports out of 170(5.88%) and we have consumed only 2% of the total area present on the board. The total ON-chip power on the board is 3.696W which is very low when compared to all other micro-controller boards. It uses very low power and gives very power efficient results.

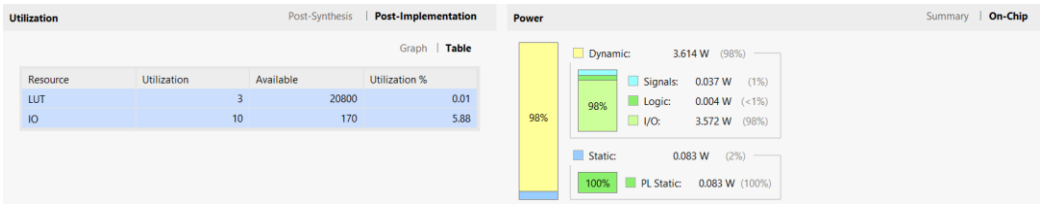

Figure 3.5. Power and Utilization Report

Table 1. Summary of Secure Home Automation Simulation Value with Input and Output values

Case	Enable	Input_value	Output_value
PIR	0	0	0
	0	1	0
	1	0	0
	1	1	1
LDR	-	0	1
		1	0
Light & Fan	-	0	0
	-	1	1

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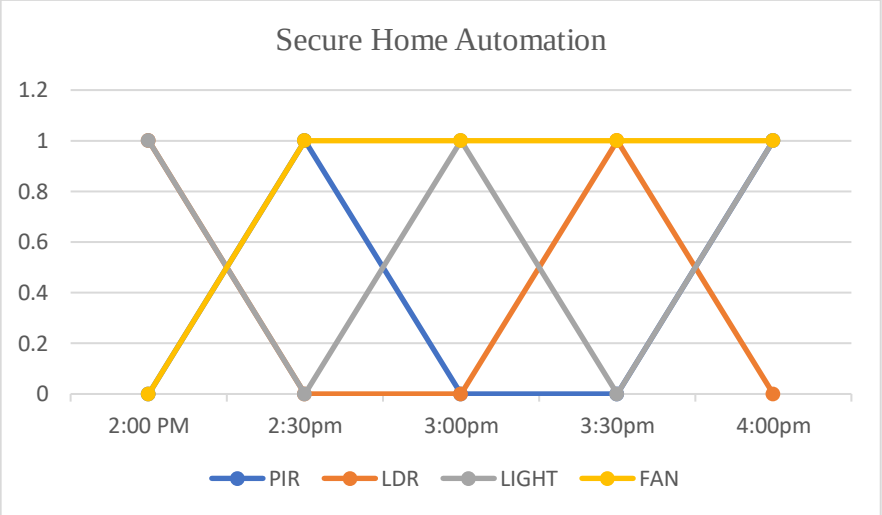

Figure 3.6 Thingspeak Software Data

4. CONCLUSION

In this research, a secure IoT-based home automation framework is provided. The proposed system was designed to sense a wide range of things, such as the motion of a person, automated light glow, and fan control, and other things[8]. Also, a communicative online application that can be used to notify any suspicious activities to the home's owner has been built. Extending the web application to an android application and exploring different activities that could take place inside or outside the house could be future directions for study aimed at enhancing the home automation system.[10],[12]

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REFERENCES

[1] R. Veerabommala and G. Arya, “Smart Home Implementation using Verilog Hardware Descriptive Language,” *Int. J. Eng. Res.*, vol. 11, no. 02.
[2] J. Alvarez, A. Acero, S. Gutierrez, P. M. Rodrigo, and A. Lay-Ekuakille, “A low cost presence detection system for smart homes,” in *2018 International Conference on Research in Intelligent and Computing in Engineering (RICE)*, San Salvador, Aug. 2018, pp. 1–6. doi: 10.1109/RICE.2018.8627901.
[3] S. Singh, C. Shekhar, and A. Vohra, “FPGA-Based Real-Time Motion Detection for Automated Video Surveillance Systems,” *Electronics*, vol. 5, no. 4, p. 10, Mar. 2016, doi: 10.3390/electronics5010010.
[4] N. Nasrudin, N. M. Ilis, T. P. Juin, T. T. K. Chun, L. W. Zhe, and F. Z. Rokhani, “Analysis of the light dependent resistor configuration for line tracking robot application,” in *2011 IEEE 7th International Colloquium on Signal Processing and its Applications*, Penang, Malaysia, Mar. 2011, pp. 500–502. doi: 10.1109/CSPA.2011.5759930.
[5] S. A. Akinwumi, A. C. Ezenwosu, T. V. Omotosho, O. O. Adewoyin, T. A. Adagunodo, and K. D. Oyeyemi, “Arduino Based Security System using Passive Infrared (PIR) Motion Sensor,” *IOP Conf. Ser. Earth Environ. Sci.*, vol. 655, no. 1, p. 012039, Feb. 2021, doi: 10.1088/1755-1315/655/1/012039.

[6] S. Sharma, J. Boddu, G. S. Charan, S. Sharma, S. Sivanantham, and K. Sivasankaran, "Home automation through FPGA controller," in *2015 Online International Conference on Green Engineering and Technologies (IC-GET)*, Coimbatore, India, Nov. 2015, pp. 1–4. doi: 10.1109/GET.2015.7453813.
[7] F. A. Silaban, S. Budiyanto, and W. K. Raharja, "Stepper motor movement design based on FPGA," *Int. J. Electr. Comput. Eng. IJECE*, vol. 10, no. 1, p. 151, Feb. 2020, doi: 10.11591/ijece.v10i1.pp151-159.
[8] M. S. Mehra, "IoT based Smart Home Automation System using Raspberry Pi," *Int. J. Eng. Res.*, vol. 11, no.07
[9] C.-P. Ooi, W.-H. Tan, S.-N. Cheong, Y.-L. Lee, V. M. Baskaran, and Y.-L. Low, "FPGA-based embedded architecture for IoT home automation application," *Indones. J. Electr. Eng. Comput. Sci.*, vol. 14, no. 2, p. 646, May 2019, doi: 10.11591/ijeecs.v14.i2.pp646-652.
[10] T. Gurav, I. Gaonkhadkar, S. Deolekar, Y. Dhanawade, and R. Kulkarni, "IOT BASED HOME AUTOMATION USING FPGA," vol. 10, no. 4, 2022.
[11] Scholar,Dept of ECE,Koneru Lakshmaiah Education Foundation,Vaddeswaram Guntur District of Andhra Pradesh, India, C. Jayaprakash, D. N. Siddaiah, and Professor,Koneru Lakshmaiah Education Foundation,Vaddeswaram Guntur District of Andhra Pradesh, India, "Sensitivity Analysis of NEMS Cantilever to Detect Volatile Organic Compounds Using Finite Element Method," *Kuwait J. Sci.*, Jul. 2022, doi: 10.48129/kjs.20501.
[12] Shovan Bhowmik, "Ensuring Important Household Item Security by Designing LDR Sensor and GSM Technology based Cost-Effective Smart Protection Box," Jul. 2021, doi: 10.5281/ZENODO.5120995.
[13] H. H. Qasim, A. E. Hamza, H. H. Ibrahim, H. A. Saeed, and M. I. Hamzah, "Design and implementation home security system and monitoring by using wireless sensor networks WSN/internet of things IOT," *Int. J. Electr. Comput. Eng. IJECE*, vol. 10, no. 3, p. 2617, Jun. 2020, doi: 10.11591/ijece.v10i3.pp2617-2624.
[14] K. A. Gani and F. Yasmin, "Home Automation System Design Using Verilog Hardware Descriptive Language," 2013.
[15] M. Ali *et al.*, "An IoT based Approach for Efficient Home Automation with ThingSpeak," *Int. J. Adv. Comput. Sci. Appl.*, vol. 11, no. 6, 2020, doi: 10.14569/IJACSA.2020.0110615.
[16] P. S. Chinchansure and C. V. Kulkarni, "Home automation system based on FPGA and GSM," in *2014 International Conference on Computer Communication and Informatics*, Coimbatore, India, Jan. 2014, pp. 1–5. doi: 10.1109/ICCCI.2014.6921803.
[17] P. Gopalaswamy and K. Miranji, "Implementation of Data Encoding and Decoding Architecture for Network on Chip," no. 7, 2015.
[18] Md. M. Islam, Md. N. Farook, S. M. G. Mostafa, and Y. Arafat, "Design and Implementation of an IoT Based Home Automation," in *2019 1st International Conference on Advances in Science, Engineering and Robotics Technology (ICASERT)*, Dhaka, Bangladesh, May 2019, pp. 1–5. doi: 10.1109/ICASERT.2019.8934606.
[19] D. Jiang, L. Nie, Z. Lv, and H. Song, "Spatio-Temporal Kronecker Compressive Sensing for Traffic Matrix Recovery," *IEEE Access*, vol. 4, pp. 3046–3053, 2016, doi: 10.1109/ACCESS.2016.2573264.
[20] K. Madhuri, B. L. Sai, and B. S. Sirisha, "A Home Automation System Design Using Hardware Descriptive Tools," *Int. J. Eng. Res.*, vol. 2, no. 7, 2013.
[21] G. Manasa, M. D. Rao, and K. Miranji, "DESIGN AND ANALYSIS OF FAST ADDITION MECHANISM FOR INTEGERS USING QUATERNARY SIGNED DIGIT NUMBER SYSTEM," vol. 05, 2014.
[22] S. K. Nagendla and K. Miranji, "IMPLEMENTATION OF HIGH SPEED-LOW POWER TRUNCATION ERROR TOLERANT ADDER," *Int. J. Electron. Electical Eng.*, pp. 239–244, Apr. 2015, doi: 10.47893/IJEEE.2015.1162.
[23] B. Narayan, S. Sandip, and P. Prakash, "Smart Security Alarm System using PIR Sensor," vol. 5, no. 9, 2021.
[24] R. Payal, A. Saxena, and B. Chanda, "Implementation of Smart Home through FPGA using Verilog Hardware Descriptive Language," in *2020 IEEE International Conference on Advent Trends in Multidisciplinary Research and Innovation (ICATMRI)*, Buldhana, India, Dec. 2020, pp. 1–6. doi: 10.1109/ICATMRI51801.2020.9398499.
[25] "Home Automation using Arduino and Smart Phone," *Int. J. Eng. Res.*, vol. 7, no. 06, 2019.