Smart Magnetic Door Lock For Elderly People Using AWS Alexa, IoT, Lambda and ESP Module

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Area of the Paper: Computer Science.
Type of the Paper: Experimental Research.
Type of Review: Peer Reviewed as per |C|O|P|E| guidance.
Indexed In: OpenAIRE.
DOI: https://doi.org/10.5281/zenodo.10467946
Google Scholar Citation: IJCSBE

How to Cite this Paper:
Chakraborty, S. & Aithal, P. S. (2023). Smart Magnetic Door Lock for Elderly People Using AWS Alexa, IoT, Lambda and ESP Module. *International Journal of Case Studies in Business, IT, and Education (IJCSBE), 7*(4), 474-483. DOI: https://doi.org/10.5281/zenodo.10467946

International Journal of Case Studies in Business, IT and Education (IJCSBE)
A Refereed International Journal of Srinivas University, India.

Crossref DOI: https://doi.org/10.47992/IJCSBE.2581.6942.0332

Paper Submission: 19/12/2023
Paper Publication: 31/12/2023

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ABSTRACT

Purpose: *Nowadays, we all are busy. From morning till night, we spent most of our time outside the house. In most of the scenarios, we struggle to fulfill our financial needs. We are bound to keep our senior citizens at home, and we are busy with work, which provides us assurance of financial health. Our senior citizen is engaged to manage the house. They are generally involved with lightweight tasks like opening the main door. But this work sometimes causes trouble for our older people if they have difficulty walking. Sometimes, they need to come from upstairs to down. For this problem, we have a solution. Without coming downstairs or in front of the main door, we must say, "Alexa, open the door" from a mobile phone. The door will open. After that, it will also lock automatically. There is no need to shut the door again.*

Design/Methodology/Approach: *We execute the project using AWS IoT, Lambda, and Alexa voice service. We create our IoT profile inside the AWS cloud. Create and upload Lambda functions to the AWS Lambda cloud services to trigger the equipment. Create Alexa skills inside the Alexa developer console to convert voice commands into text.*

Findings/Result: *After executing several experiments, we observed that our system ran well without any false triggering. We also observed that the system performance is good if the internet is speedy enough and the voice is clear and electronically understandable.*

Originality/Value: *Much research has been done on automatic door-opening systems for older adults. But most of the architecture is less feasible for daily hassle-free use. So, considering all aspects like consistency, security, robustness, and fast response, we decided to implement this architecture, which we can say is a unique approach and provides value to the user's daily life.*

Paper Type: *Experimental-based research*

Keywords: *AWS IoT, Lambda & API Gateway, Intelligent Door Lock, IoT Device Creation, Smart Home Systems, Serverless IoT Development.*

1. INTRODUCTION :

Problem statement: Nowadays, we are all bound by busy schedules. From morning till night, we are basically outside of the house. Someone always needs to stay at our house for many reasons. Some parcels may have arrived, and we need to pick them up. There may be an electrical meter reading and an online shopping delivery person comes and needs to pick it up. And many more. So people must stay home to attend or pick up the materials. Generally, middle-aged people are busy with outside jobs or inside essential work. So, in most scenarios, our older adults are engaged to do the task. Nowadays, due to our lifestyle, we all suffer from physical illness. For that reason, sometimes our movement from upstairs to down is hectic. It can also be risky when an elder moves to open the door. There is something to open the door from just voice commands. A couple of decades before, it was not possible. But now it is possible to do. If we have an Echo Dot or other devices, we can also use them. When older adults say voice commands in front of the app, the voice will trigger the magnetic lock, and the door will open.

Essential findings of others in this field: Several research studies have been done to help older adults overcome the opening door. One research work (Saputra et al. (2021). [1]) was done to open the door using face recognition. When the system recognizes the face, the door will open. But this system has an issue. It is okay for family members, regular visitors, or trusted people. Only registered faces can open the door. In the research work, Cho, M. G. 2015 [4] has developed a smart home based on the Arduino framework. This system was focused on those older people who live alone. Only a little information is available on opening the door. One good research work (Joy et al. (2022). [7]) was carried out on automatic door opening and closing based on face and voice recognition when the house owner is not present inside the house. In the research work (Pardeshi et al. (2023). [8] proposed a system where three-level authentication is needed. But the door opening and closing should be a quick process. The three-level authentication made accessing the door a lengthy process. Sometimes, it may create a question mark of acceptability. Upadhyay et al. (2020). [10] developed an intelligent door-locking system based on image processing. Image processing is reliable, but sometimes, it cannot detect images or takes more time to detect the face. It is not feasible when the system is installed in a crowded place.
What study is done in this paper: we study here to facilitate opening the main entrance to the older adults using voice command. In most scenarios, they open the door by reaching in front of it while walking. It is not possible to walk sometimes somehow. So, we focussed here on opening the door process quickly using the latest technological innovations.
Principal conclusion: now we are concluding that several research projects are available on door opening technology; after studying all the available proposals, voice technology might be the best technology from the perspective of speed and security feasible for older people. It is said to open the door that it. It is optional to carry the phone. It is anywhere in the room, and the Alexa app or device reaches the voice. The door will open instantly. This is the beauty of voice-over technology.

2. REVIEW OF LITERATURE/ CURRENT STATUS :

Several works have been done in the field of automatic door-opening technology. In table 1, we summarize such research work.

Table 1: Review of technology used and research on the door opening process.

S. No.	Technology/Algorithm/ Module/Components	Focus	Reference
1	Face Recognition, Smart Door lock	Innovative and real-time door lock system for an elderly user based on face recognition	Saputra et al. (2021). [1]
2	Zigbee, Amazon Echo, Atmega16, Robot Rovio	Home Monitoring for Elderly People	Rituraj, A. et al. (2019). [2]
3	smart door lock, Kano model, user journey map	intelligent door lock design based on an extended Kano model	Xiong, Z. Y. (2021). [3]
4	Arduino	Smart Home System for the Elderly	Cho, M. G. (2015). [4]
5	GPS, Accelerometer Sensor. Temperature Sensor, NodeMCU	Automation system for elderly and disabled people	Arun Francis, G. et al. (2021). [5]
6	various sensors	brilliant house for older persons and persons with physical disabilities	Stefanov, D. H. et al. (2004). [6]
7	IoT, Door Lock	Advanced Computing in IoT for Door Lock Automation	Joy, S. et al. (2022). [7]
8	Access Control System, Digital Door Lock mechanism	Access Control System for Digital Door Lock	Pardeshi, A. et al. (2023). [8]
9	Internet of Things	IoT-supported smart homes for the elderly	Sokullu, R. et al. (2020). [9]

10	image classification, WLAN	Design of intelligent door closer system	Upadhyay, J. et al. (2020). [10]
11	Wearable, Visual sensors, robotics, HMI	Innovative technology for aging, disability, and independence	Mann, W. C. (2005). [11]
12	Bluetooth	Door Lock System Using Bluetooth Technology	Afreen, S. (2021) [12]

To execute the current research work, we carried out various research projects listed in Table 2.

Table 2: The listed research projects which are used in this project.

S. No.	Technology/Algorithm/ Module/Components	Focus	Reference
1	Sinric Pro, C#	How to make IoT in C# using Sinric Pro	Chakraborty, et al. (2022). [13]
2	C# WPF, Sinric Pro IoT framework	Virtual IoT Device in C# WPF Using Sinric Pro	Chakraborty, et al. (2022). [14]
3	AWS IoT Framework	Create An IoT Inside the AWS Cloud	Chakraborty et al. (2023). [15]
4	AWS IoT, ESP module, Arduino framework	Create a Physical IoT Device Using AWS and ESP Module	Chakraborty et al. (2023). [16]
5	AWS IoT, ESP32 module, Arduino framework, Dot net framework(C#)	Create Multiple IoT Device Controller Using AWS, ESP32, And C#	Chakraborty et al. (2023). [17]
6	AWS IoT, ESP32 module, Arduino framework, Dot net framework(C#)	Create Our Desktop IoT Soft-Switchboard Using AWS, ESP32, and C#	Chakraborty et al. (2023). [18]
7	AWS Lambda, Dot net framework(C#)	Create A Lambda Function for Our IoT Device In The AWS Cloud Using C#	Chakraborty et al. (2023). [19]
8	AWS IoT, ESP 8266 module, Dot net framework(C#)	IoT-Based Industrial Debug Message Display Using AWS, ESP8266, And C#	Chakraborty et al. (2023). [20]
9	AWS IoT, ESP 8266 module	IoT-Based Switch Board for Kids Using ESP Module And AWS	Chakraborty et al. (2023). [21]
10	AWS IoT, Alexa developer console, Lambda plugins for C#, ESP32 module	Create an Alexa-Enabled IoT Device Using C#, AWS Lambda and ESP Module	Chakraborty et al. (2023). [22]
11	AWS IoT, Alexa developer console, Lambda console, ESP32 module, Dot Net Framework (C#)	Alexa Enabled IoT Device Simulation Using C# And AWS Lambda	Chakraborty et al. (2023). [23]

12	AWS Alexa developer console	Create an Alexa Skill for Our IoT Device Inside the AWS Cloud	Chakraborty et al. (2023). [24]
13	CoppeliaSim robot simulator, C# language	Smart Home Simulation in CoppeliaSim Using C# Through WebSocket	Chakraborty et al. (2023). [25]
14	CoppeliaSim robot simulator, C# language, Websocket module	Automated Test Equipment Simulation In CoppeliaSim Using C# Over WebSocket	Chakraborty et al. (2023). [26]
15	Bitbucket, GitHub, and SourceTree	A Practical Approach To GIT Using Bitbucket, GitHub, and SourceTree	Chakraborty et al. (2022). [27]
16	Modbus, Dot net framework(C#)	Industrial Automation Debug Message Display Over Modbus RTU Using C#	Chakraborty et al. (2023). [28]
17	Modbus, Dot net framework(C#)	Modbus Data Provider for Automation Researcher Using C#	Chakraborty et al. (2023). [29]
18	Dot net framework(C#)	MVVM Demonstration Using C# WPF	Chakraborty et al. (2023). [30]

3. OBJECTIVES OF THE PAPER :

The paper is experimental and follows a research model of experimental-based research work where we meet several objects, which are as follows:

(1) To study the feasibility of the work in real-world scenarios.
(2) To test the system functionality that we proposed,
(3) To compare the effectiveness of the research project with the existing available system.
(4) To evaluate the system performance over the cloud.
(5) To prove the possibility of implementing the Alexa technology into everyday life.
(6) To develop a robust system that will be treated as an essential component in everyday life.
(7) To interpret how to trigger the physical device over the cloud using Alexa.
(8) To create a helpful system in daily life, especially for older people.
(9) To identify the bottleneck to implement this kind of system.
(10) To determine whether to continue the research for everyday use.

4. METHODOLOGY :

The approach and methodology for creating an intelligent door lock system involve the following steps: System Design: Plan the system architecture, considering components like AWS IoT Core, Lambda functions, API Gateway, and IoT devices like ESP8266 or ESP32 for connectivity. Security Features: Integrate security measures such as face recognition based on algorithms like local binary pattern histogram for authentication. IoT Connectivity: Utilize AWS IoT services for seamless connectivity, leveraging the capabilities of AWS Lambda and API Gateway for communication between IoT devices and the cloud. User Interaction: Incorporate user-friendly interfaces, enabling voice control through integration with Amazon Echo or similar smart home systems. Figure 1 depicts the project block diagram.

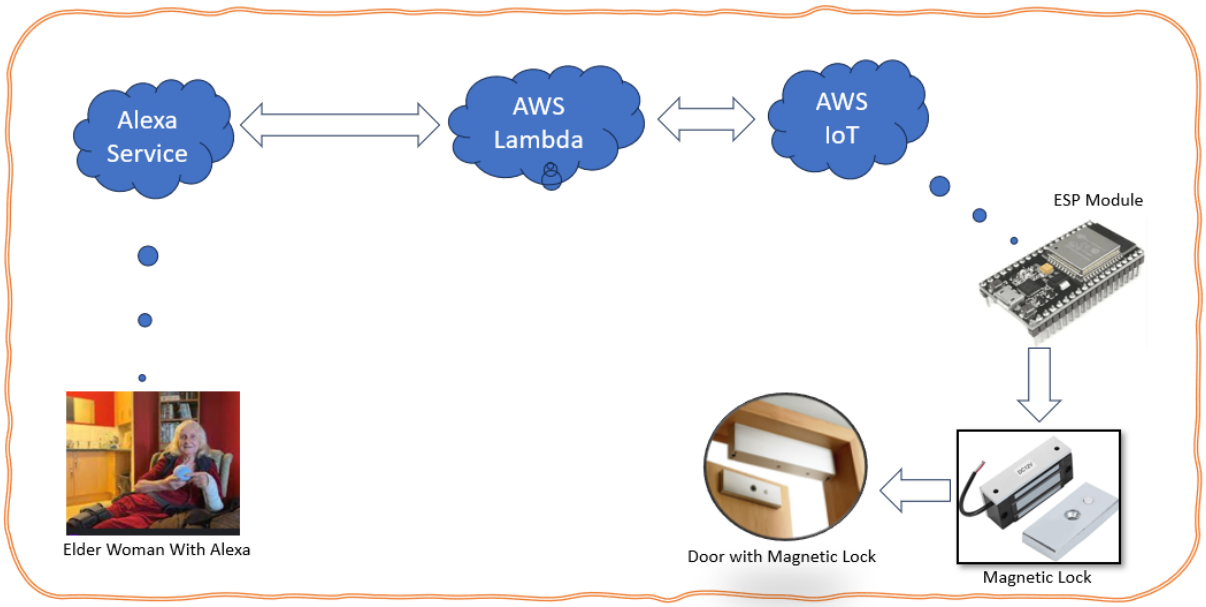

Fig. 1: Project Block Diagram

5. EXPERIMENT :

To execute the project in the researcher lab to strengthen the acquired knowledge from this project, we need to follow the below steps:

1) Arrange the components like door lock magnet, ESP module, power adaptor, etc.
2) Complete the hardware connection. If the researcher cannot do that, get help from experts who know hardware connections and soldering.
3) Create an IoT profile in the AWS cloud. The paper [15] might be a practical guide to do that.
4) Write firmware inside the ESP module. The paper [16] can be a good reference for this task.
5) From the AWS cloud IoT console, using the MQTT test tool, check the door magnet is triggered to open the door.
6) Install Visual Studio's latest edition. We need to customize the IDE for the C# language. Create a new project. Add AWS lambda module using Nuget package manager. To create the Lambda function, the paper can guide [19] us on how to do that.
7) Check the AWS IoT shadow register is updating from the Lambda function. If it does not perform as expected, debug properly.
8) Create an account inside the Alexa developer console if not present. Inside the Alexa, create a custom skill. Create intent based on user utterance. The paper [22] can guide us in creating Alexa custom skills.
9) After Alexa skill development, Inside the console, there is the skill test interface. We need to test the skill from here. Type the utterance, execute and test the lambda function, return the response, and update the IoT shadow register. If not, check the code and lambda endpoints are added properly inside the Alexa skill configuration interface.
10) Inside the mobile phone, install Alexa from the Play Store. Add an Alexa account. The paper [22][23][24] provides in-depth information on how we will do that.
11) from the mobile phone, voice commands are sent to open or close the door. If everything is fine, the door magnet should activate or deactivate simultaneously. If it does not perform well, debug carefully.

6. RESULTS & DISCUSSIONS :

We deploy the project in a practical field. The overall performance is good. The response time is less than 5 seconds, which is ok for home use. The domestic door has a low rush tolerance. Despite that, less response time is expected. We worked with a 4G network backbone. The response time might be shorter if the internet is faster, like 5G. Table 3 depicts the response time, as we noticed.

Table 3: The sub-system response time

S. No.	Project Subsystem	Activity	Response Time (milliseconds)	Comments
1	ESP Module	Trigger the magnet	~100	acceptable
2	AWS IoT	Reach response when changing the shadow register	~1000	acceptable
3	Lambda to IoT cloud	To change the shadow register	~100	OK
4	Alexa to Lambda function	To reach the command	~100	OK
5	Alexa response	To get the response	~3000	Less is desirable

7. ANALYSIS / Comparison OF RESULTS :

The experiment shows that the inter-cloud-to-cloud communication time is significant due to aws internal process. It internally communicates one service to another service. External communication is more time-consuming. When an echo dot or mobile application receives data, it converts voice to voice token, which is transferrable to the cloud. That takes a tiny bit of time. But when the voice token propagates over the net, it takes longer than the server's internal process. It consumes two times. One is a voice token, and one side receives the response command from the Lambda services, again receives it by Alexa services, and finally receives it by the device. So, the scenario shows that the complete timing is acceptable for domestic uses. Improving local processing procedures or internet speed for factories or crowded palaces is necessary. Then, it can be permitted.

8. SUGGESTIONS / RECOMMENDATIONS :

- When we work with AWS services. We keep ourselves calm and quiet. Because the complete process is inherently a little bit complicated for the new user. It is straightforward for another project to execute when it is absorbed.
- Once the researcher completes the project. We provided a couple of projects [25][21][20][17] on a combination of IoT and AWS. Those can be practiced for more and better experience.

9. CONCLUSION :

The integration of Amazon Web Services (AWS) IoT, Lambda, and IoT devices like ESP modules has ushered in a new era of innovative door-locking systems, especially in catering to the needs of elderly individuals. Through the amalgamation of these technologies, the development of an "Alexa Enabled Magnetic Door Lock for Elderly People" has been conceptualized, providing an advanced, user-friendly, and secure solution for home security. This door lock system leverages the power of voice commands through Alexa, enhancing accessibility by eliminating the need for physical keys. Implementing AWS IoT Core and Lambda functions ensures a secure and auditable keyless entry system. Furthermore, these systems contribute to a cost-effective and efficient approach to home security, bridging the gap for the elderly population. This amalgamation of technologies offers older people enhanced security and ease of use, creating a smart home environment that aligns with their needs. The continuous evolution and integration of AWS services with IoT devices hold promise for further advancements in smart home security systems and assistive technologies.

10. ACKNOWLEDGEMENT :

I extend my heartfelt gratitude to the following individuals and organizations who contributed to the successful completion of this research project:
Dr. P. S. Aithal: I am deeply thankful to my supervisor, P. S. Aithal, sir, for their invaluable guidance, support, and encouragement throughout this endeavor.
Family and Friends: I sincerely appreciate my family and friends' unwavering support, understanding, and motivation during this research journey.

Srinivas University: I am grateful to Srinivas University for providing the resources, facilities, and assistance that facilitated this study.
Colleagues and Participants: Thanks to everyone who participated in this study and offered their insights, cooperation, and time.
This work would not have been possible without the collective help and encouragement of these remarkable individuals and institutions.

11. LIMITATIONS :

1) **Scope Restriction**: The research might have limitations due to a restricted scope, focusing solely on specific variables or a particular demographic, which might limit the generalizability of the findings. Recognizing Contributions: Acknowledge In the Research Paper.
2) **Data Collection Constraints**: Limited access to data sources or constraints in data quality, reliability, or quantity might affect the comprehensiveness and depth of the analysis.
3) **Methodological Limitations**: Potential flaws or limitations in the chosen research methodology, such as biases, sample size inadequacy, or inherent method constraints, could impact the accuracy and validity of the results—acknowledgments Example for an Academic Research Paper.
4) **Time and Resource Constraints**: Constraints in time, budget, or resources may have influenced the research process, affecting the depth of investigation or the implementation of specific methodologies—acknowledgment For Thesis, Dissertation, or Report.
5) **External Factors**: External influences, such as uncontrollable variables, environmental changes, or evolving conditions, might have impacted the research outcomes beyond the researcher's control.

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